To be discharged or not to be discharged, that's the question about spent fuel pool water

Dave Lochbaum
April 2022

Clues to the answer may be in how spent fuel pool water was handled, or mishandled, in the past.

First, consider over 100,000 gallons of spent fuel pool water leaked from a spent fuel pool at the Edwin I. Hatch nuclear plant in Georgia.

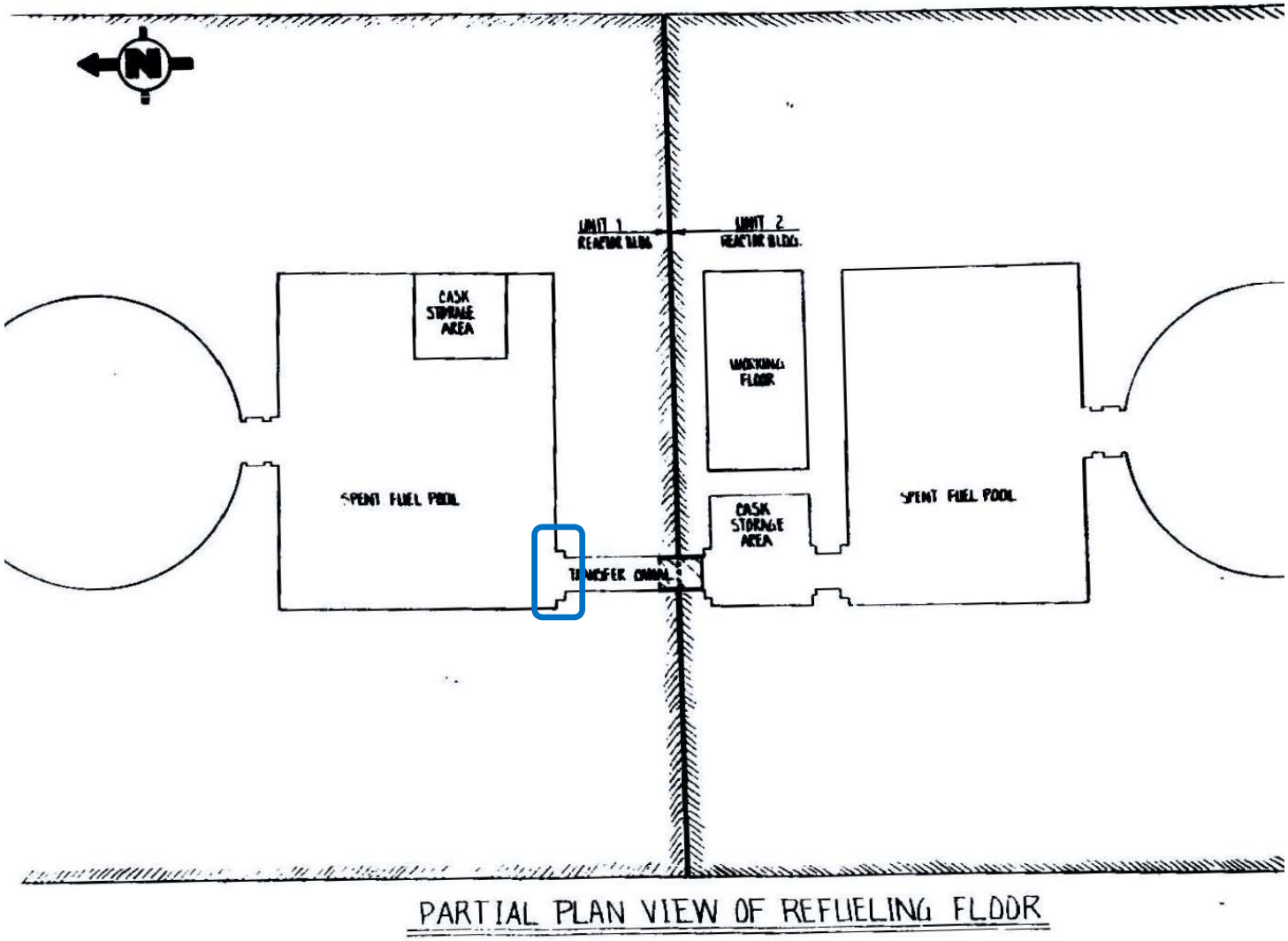
December 1986:

Spent fuel pool leak at the Edwin I. Hatch nuclear plant in Georgia

* For disclosure, the author worked as the radwaste system engineer and a reactor engineer in the second half of 1979

"On December 2, 1986, Plant Hatch Unit I was on-line at 100% power. At approximately 10:00 p.m. a Plant Equipment Operator closed a service air hose station valve which he found cracked open. The operator was unaware that this valve was the supply isolation valve to the pressure regulator for the spent fuel pool transfer canal inflatable seal. Over the next 24 hours, air pressure in the inflatable seal decreased ... allowing spent fuel pool water to enter the sealing material between the Unit I and Unit II Reactor Buildings and between the Reactor Buildings and the Turbine Building. Several instances of leaking water inside plant buildings were reported between 2:00 p.m. and 10:00 p.m. on December 3, 1986."

Source: Georgia Department of Natural Resources, *Loss of Spent Fuel Pool Water at the Edwin I. Hatch Nuclear Plant, 3 December 1986,* December 19, 1986.



PARTIAL PLAN VIEW OF REFUELING FLOOR

The transfer canal cross-connects the Unit 1 and Unit 2 spent fuel pools.

Gates, when their inflatable seals are inflated, isolate pool(s) from the transfer canal.

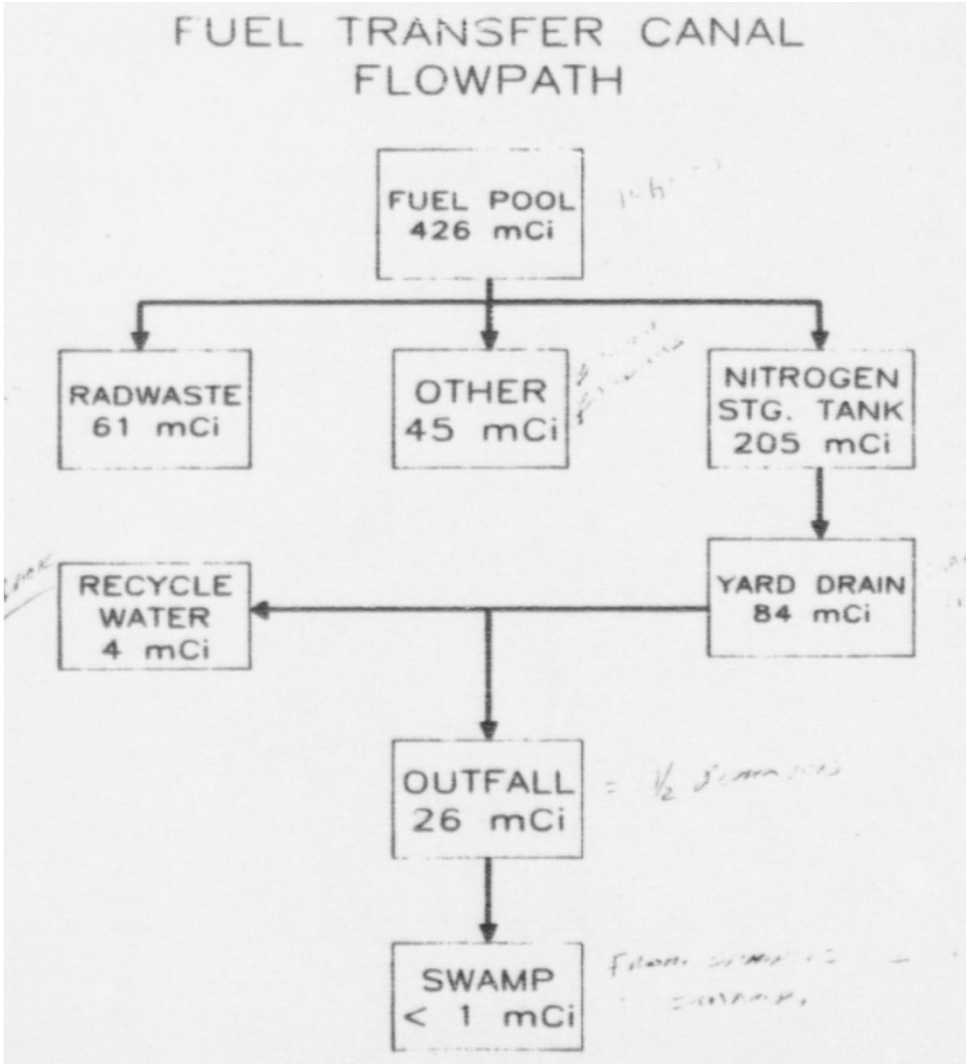
Source: Nuclear Regulatory Commission, *Enforcement Conference Meeting Summary*, February 4, 1987. (ML20245B845)

"Technical analyses determined that approximately 141,500 gallons of water leaked from the spent fuel pool during the period in which the transfer canal seal was deflated. Approximately 17,000 gallons was recovered in the Unit I and II sumps, leaving some 124,500 unaccounted for. ... Some of the water eventually entered at least one site storm drain which drained to a swampy area to the northeast of the plant site behind the cooling towers."

"Initial concentrations of radioactivity in undiluted spent fuel pool water were in excess of 50 times the Maximum Permissible Concentration (MPC) for water for unrestricted access. At the storm drain outfall, concentrations were roughly equivalent to MPC levels."

Source: Georgia Department of Natural Resources, *Loss of Spent Fuel Pool Water at the Edwin I. Hatch Nuclear Plant, 3 December 1986,* December 19, 1986.

Nitrogen Storage Tank area (soil)	205 mCi
Sludge removed from storm drain	84 mCi
Soil/vegetation removed from the creekbed	12 mCi
Soil/vegetation remaining in creekbed	14 mCi
Removed from treated water	12 mCi
Routine liquid radwaste	2 mCi
Remaining in swamp	0.5 mCi
	329.5 mCi



Source: Georgia Department of Natural Resources, *Loss of Spent Fuel Pool Water at the Edwin I. Hatch Nuclear Plant, 3 December 1986,* December 19, 1986.

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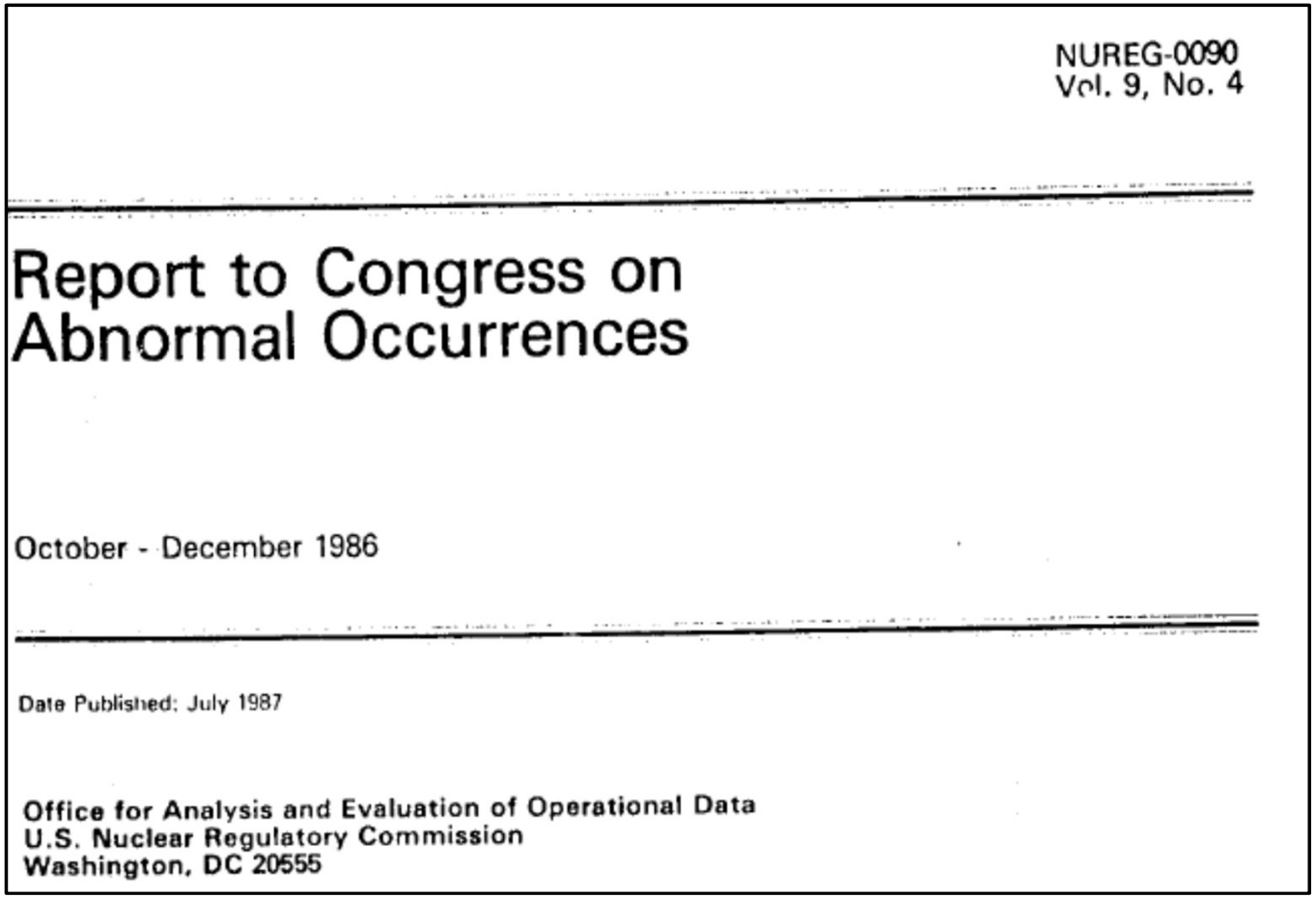


NUREG-0090
Vol. 9, No. 4

Report to Congress on Abnormal Occurrences

October - December 1986

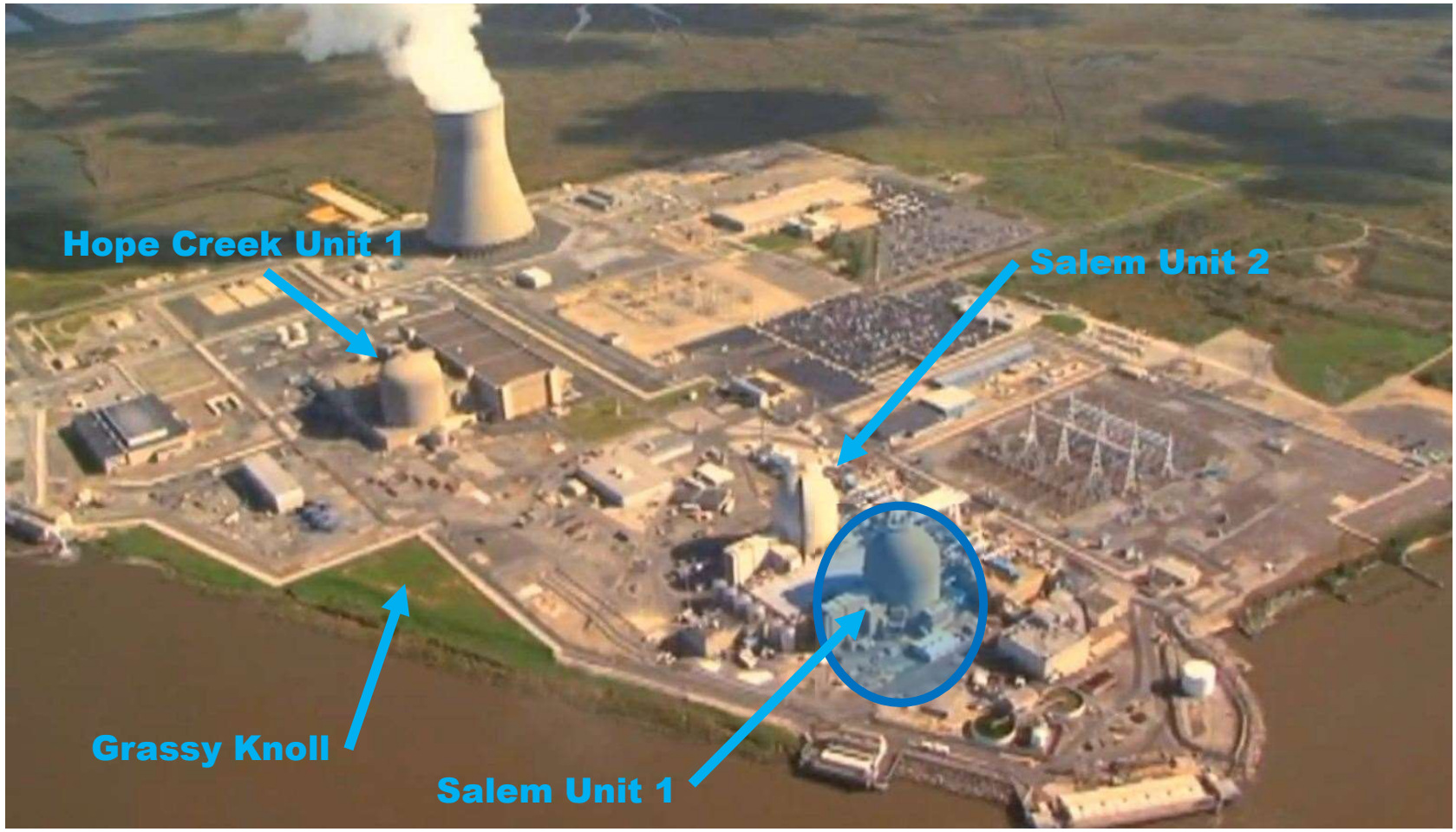
Date Published: July 1987

Office for Analysis and Evaluation of Operational Data
U.S. Nuclear Regulatory Commission
Washington, DC 20555

The NRC informed the US Congress about Hatch's spent fuel pool leak.

NRC told Congress it proposed a $50,000 civil penalty on April 8, 1987, on the owner for the leak, which the owner paid - setting the market price for contaminated swamp water at 40 cents a gallon.

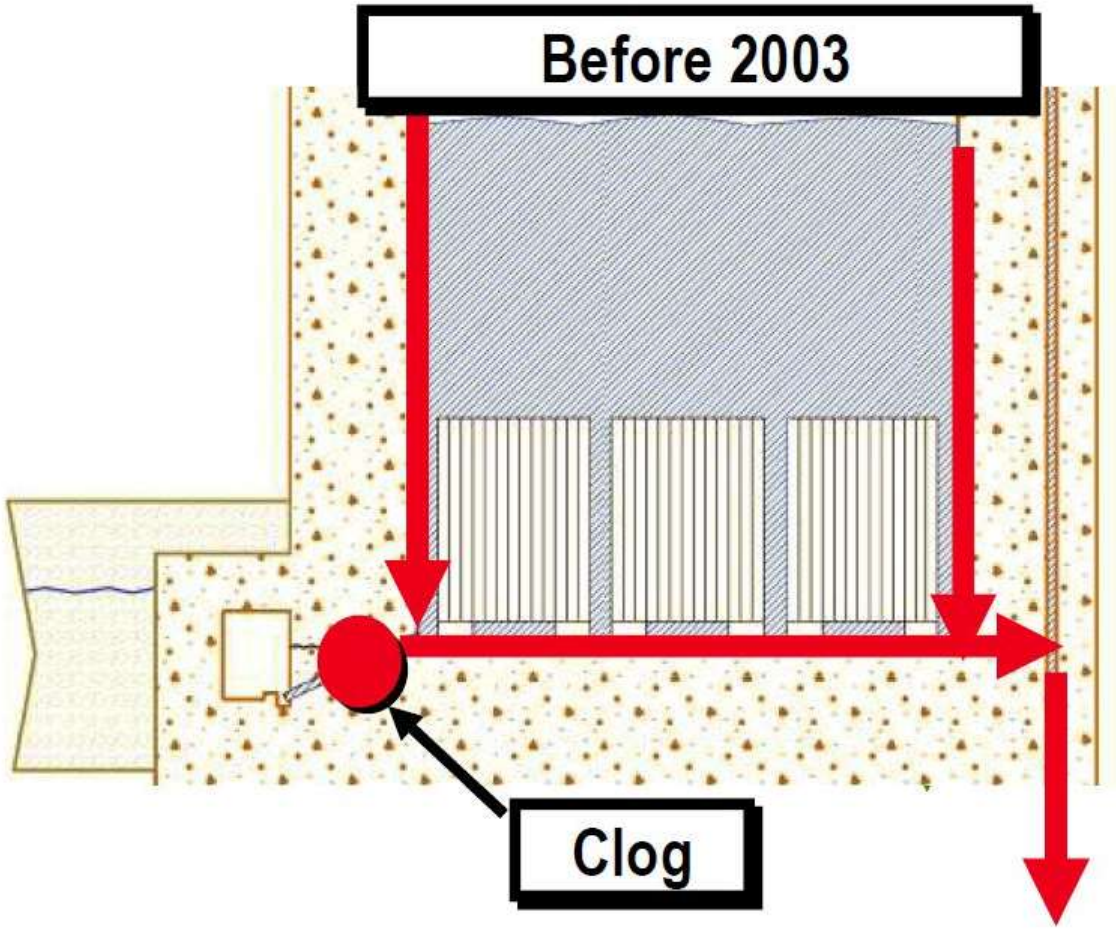
Now, consider the water leaking from the Unit 1 spent fuel pool at the Salem nuclear plant in New Jersey over an estimated 4.7 to 9 years.

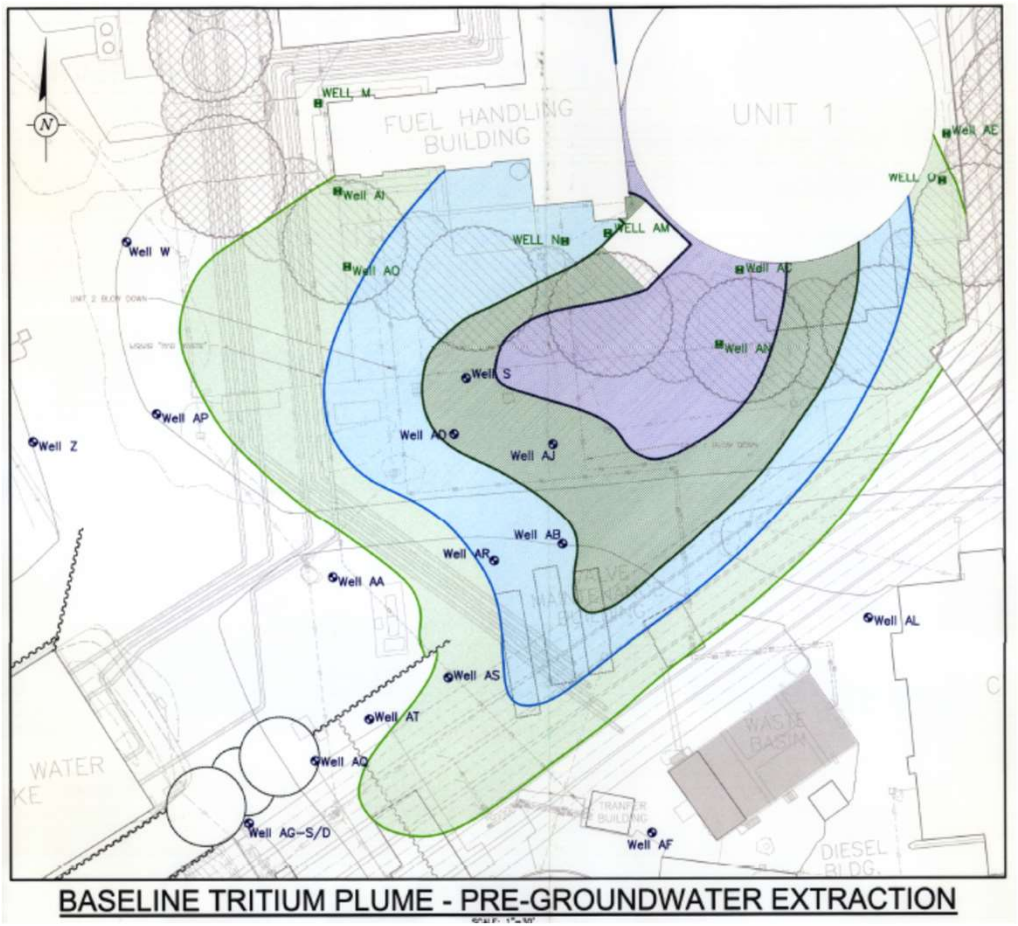


On September 18, 2002, radioactive contamination was detected on the feet of workers leaving a Unit 1 building at the Salem nuclear plant in New Jersey.

The search for the source of the contamination led to the discovery of water leaking from the Unit 1 spent fuel pool into the ground.

The concrete walls of the pool had a stainless steel liner. Water leaking through the liner was designed to flow through a drain alerting workers to the leak. But the drain was clogged.



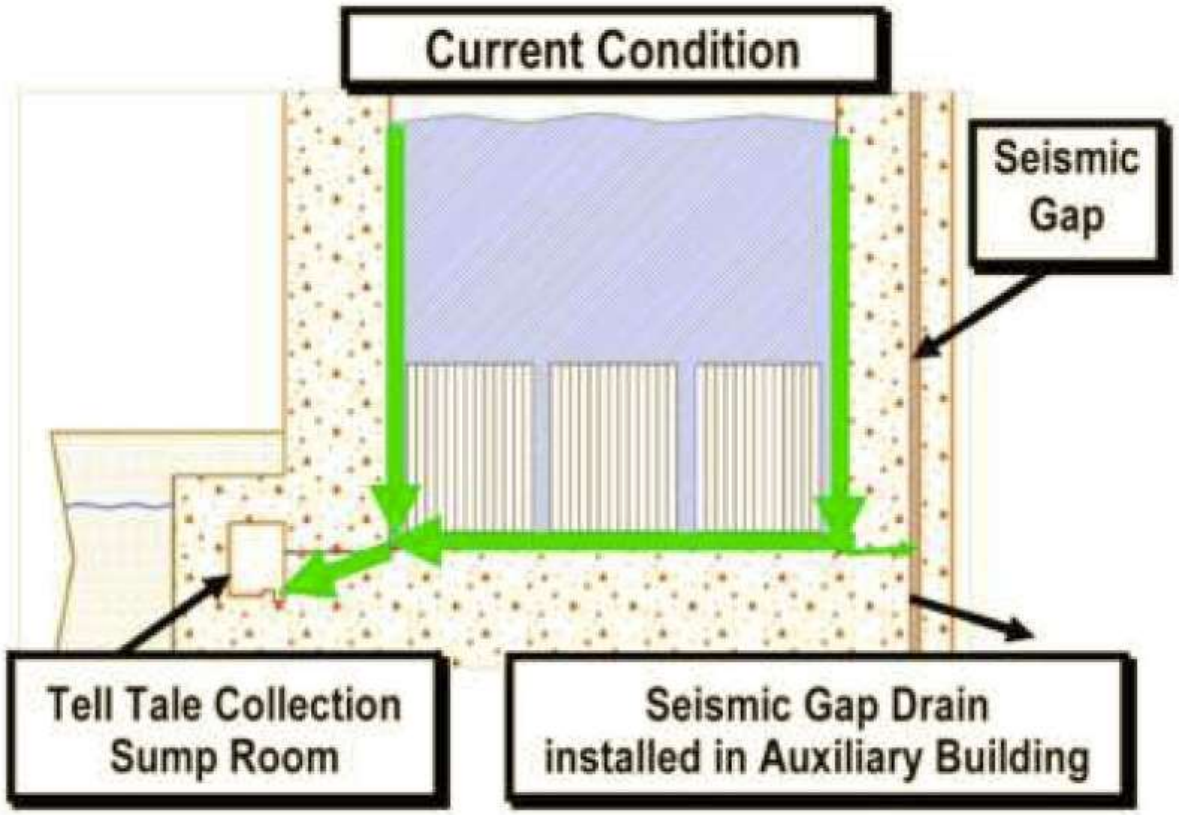


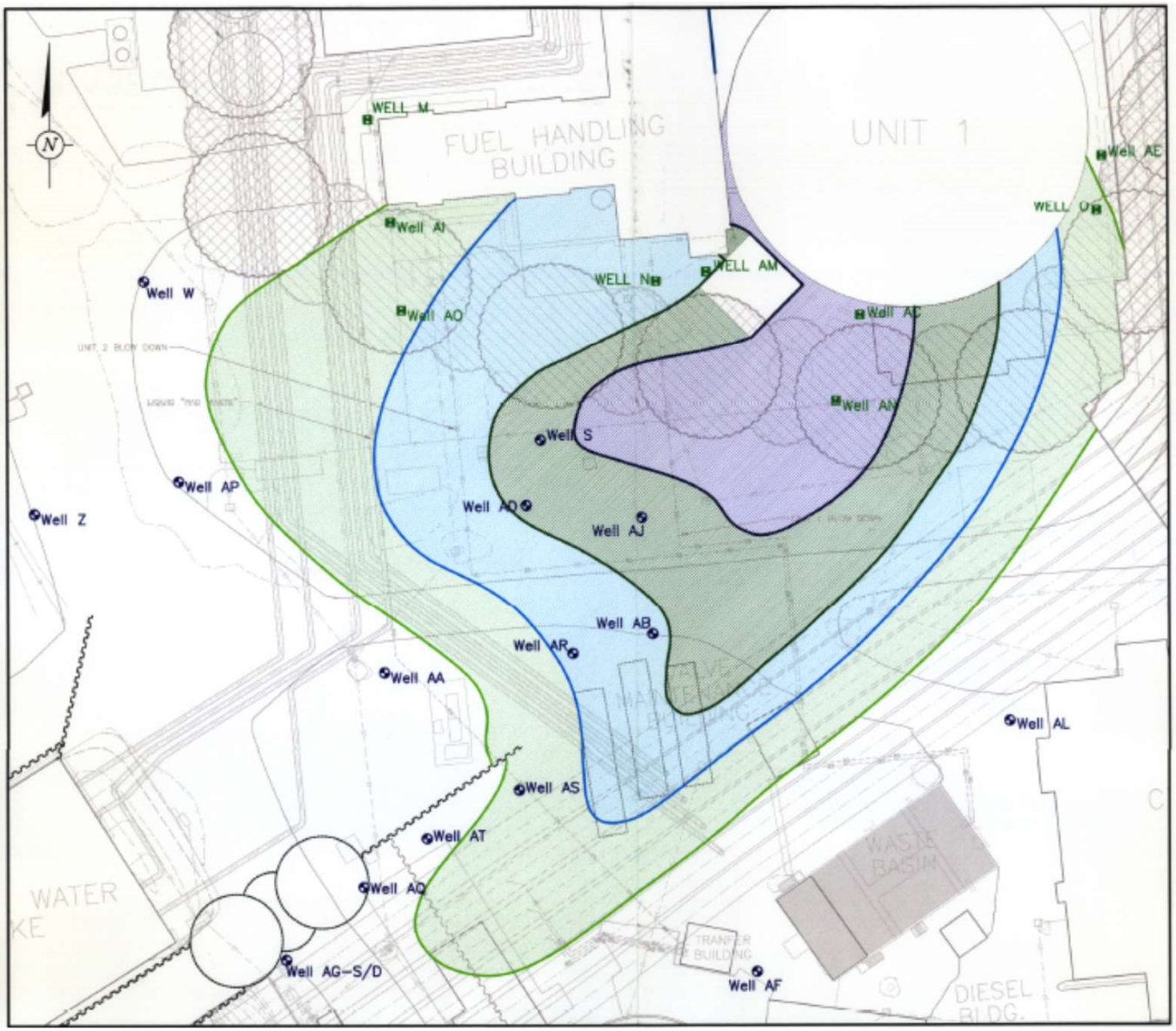
BASELINE TRITIUM PLUME - PRE-GROUNDWATER EXTRACTION

The clogged drain allowed water leaked from the Unit 1 spent fuel pool to back up and flow out through a seismic gap between the containment building and auxiliary building into the ground.

Analysis of samples from monitoring wells indicated the leakage began sometime between 1994 and 1999.

The leak was stopped by unclogging the drain line and by installing a line to drain any water collecting in the seismic gap.





The tritium levels measured in monitoring wells exceeded EPA's drinking water standard (20,000 pCi/L):

Well S: 3,530,000 pCi/L

Well M: 126,000 pCi/L

Well N: 69,000 pCi/L

Well AC: 15,000,000 pCi/L

Well AB: 409,000 pCi/L

Well AD: 487,000 pCi/L

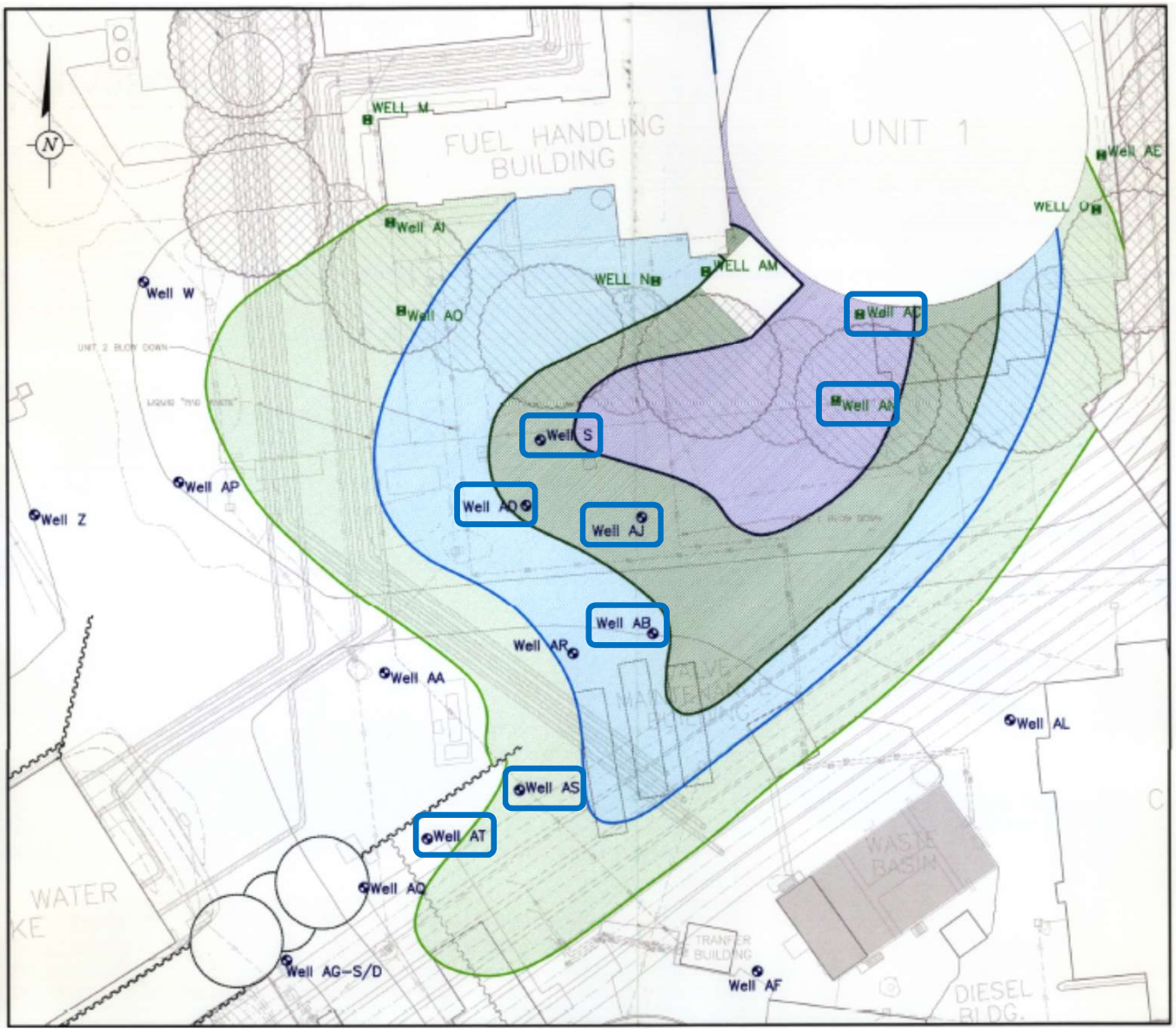
"*GRS* [groundwater remediation system] *operations were initiated on February 16, 2005. ... As of December 2011, the GRS has recovered nearly 28 million gallons of groundwater.*"

The groundwater remediation system has also been called the groundwater extraction system. By any label, the thing sucked contaminated water out of the ground around Salem Unit 1.

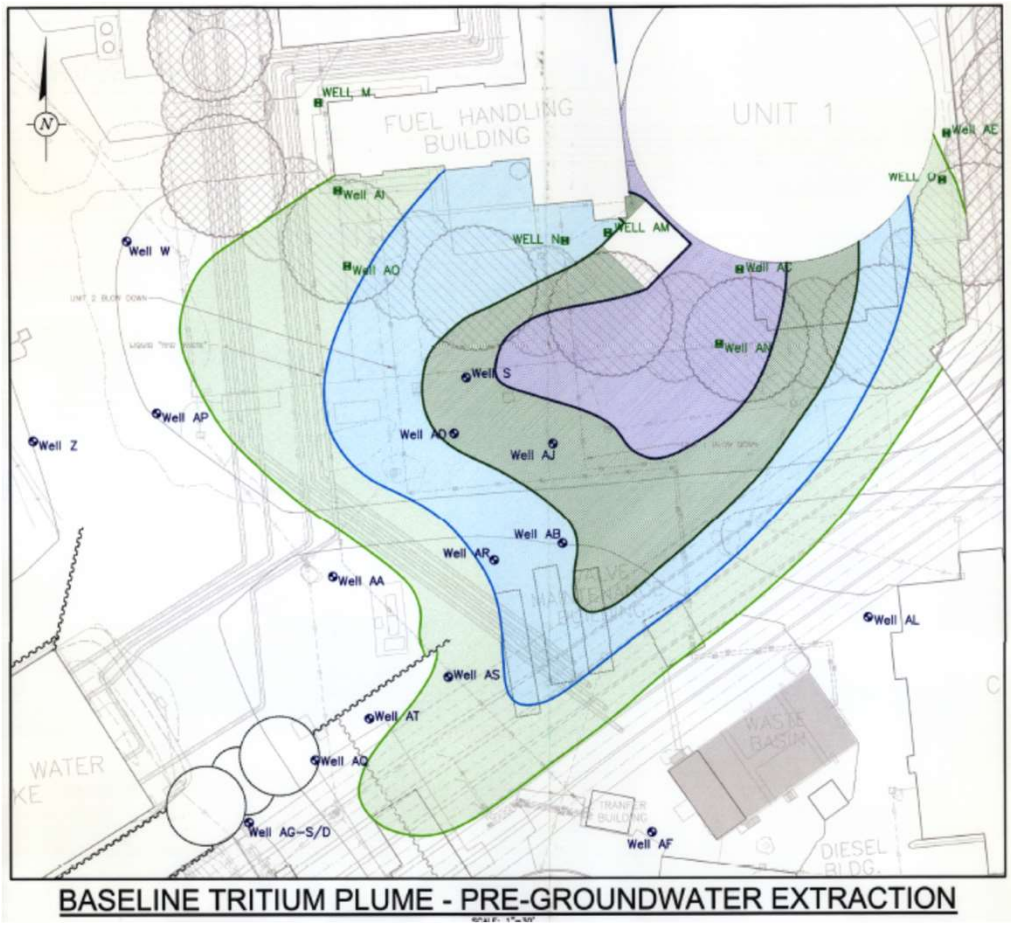
Source: PSEG Nuclear, LLC, *Quarterly Remedial Action Progress Report, Fourth Quarter 2011 PSEG Nuclear LLC, Salem Generating Station, May 21, 2012. (ML14093A437)*

"*The GES* [groundwater extraction system] *system consists of the extraction of groundwater from Wells S, AB, AD, AJ, AN, AS and AT. Well AO continues to be out of service to prevent interference with diesel fuel oil recovery operations and Well S has been operating intermittently as a result of the well's low yield. Additionally, Wells AO, AN, AS and AT required wiring modifications and were temporarily out of service. All eight extraction well pumps are currently in service.*"

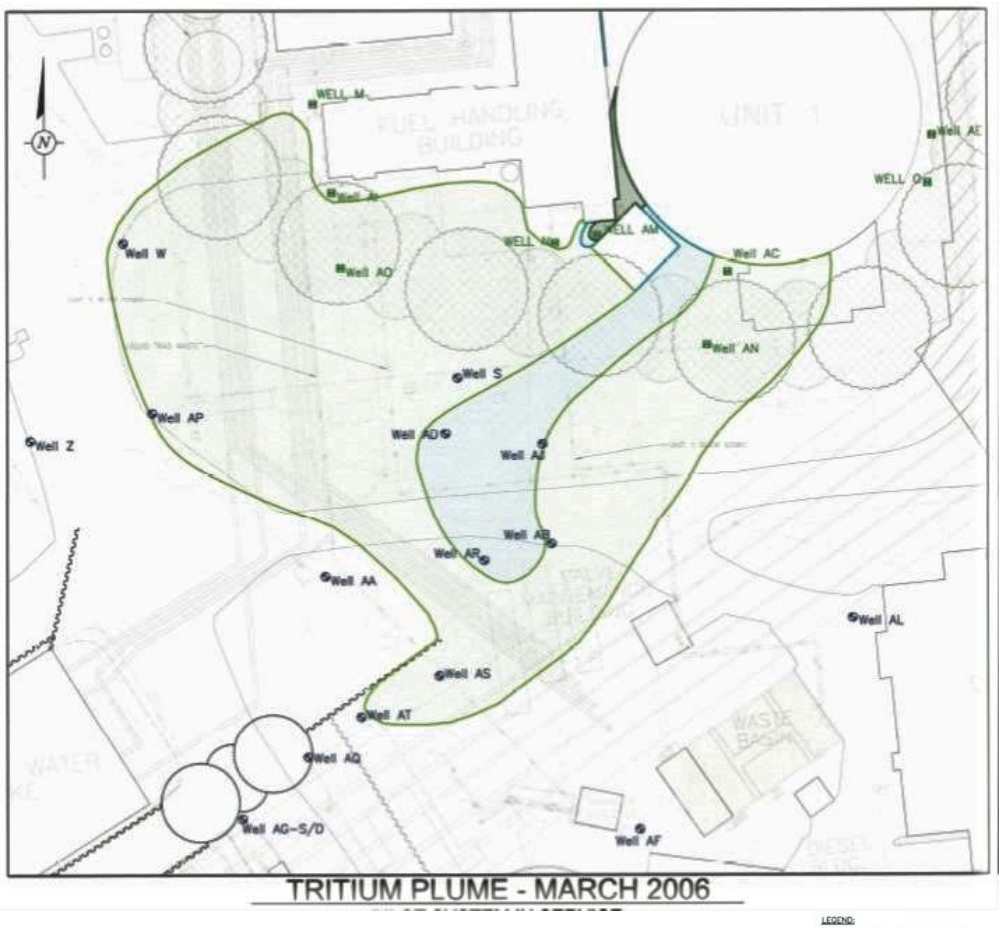
Source: PSEG Nuclear, LLC, ***Quarterly Remedial Action Progress Report, Third Quarter 2005 PSEG Nuclear LLC, Salem Generating Station, May 11, 2005.***



Wells used to extract contaminated groundwater from around the Salem Unit 1 area.



BASELINE TRITIUM PLUME - PRE-GROUNDWATER EXTRACTION



TRITIUM PLUME - MARCH 2006

LEGEND:

WELL R■ MONITORING WELL SCREENED IN THE SHALLOW, WATER-BEARING UNIT WITHIN THE LIMITS OF THE COFFERDAM.

WELL S● MONITORING WELL SCREENED IN THE SHALLOW, WATER-BEARING UNIT OUTSIDE THE LIMITS OF THE COFFERDAM.

LIMIT OF GROUNDWATER WITH TRITIUM ABOVE 1,000,000 pCi/L

LIMIT OF GROUNDWATER WITH TRITIUM ABOVE 500,000 pCi/L

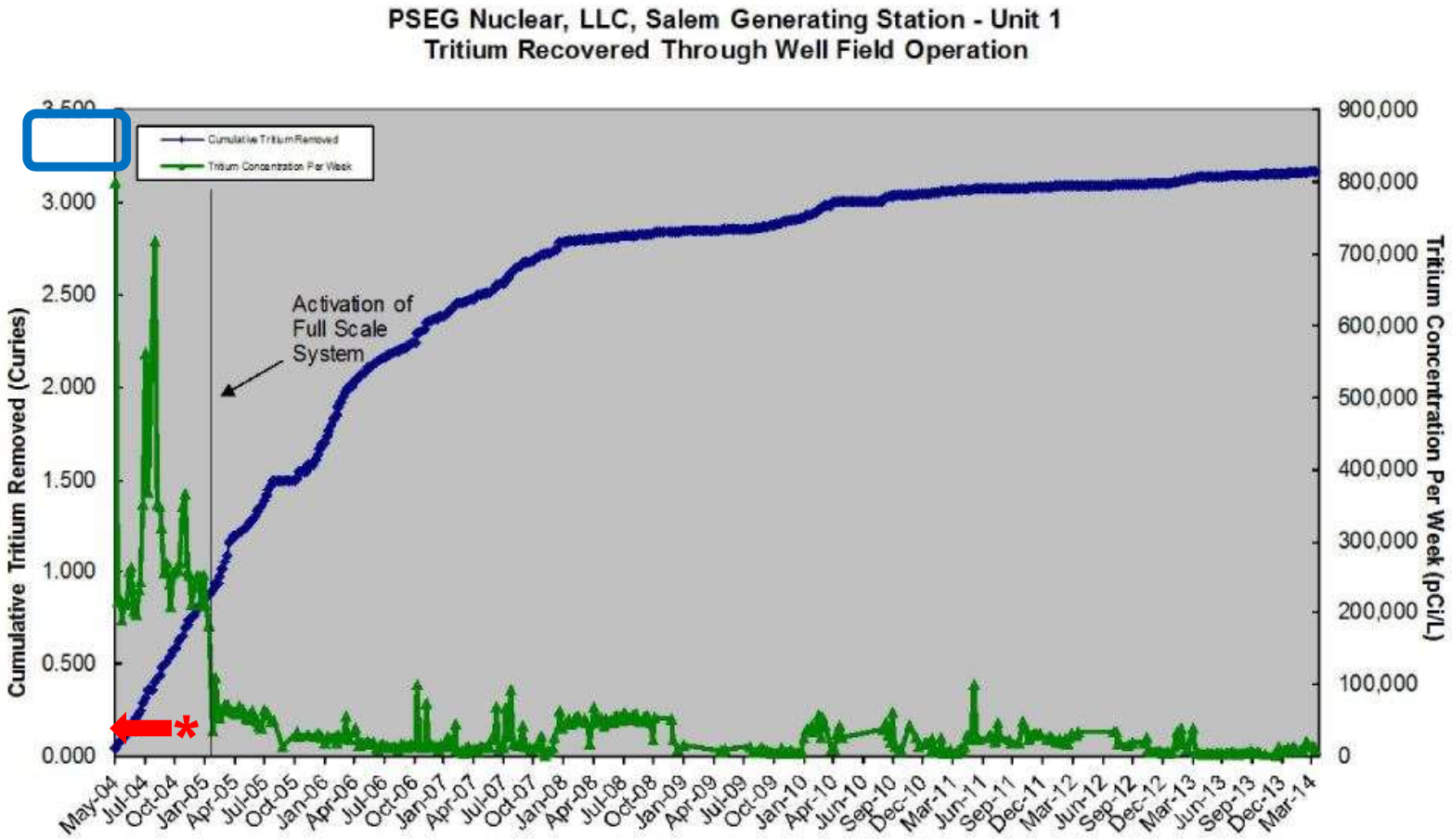
LIMIT OF GROUNDWATER WITH TRITIUM ABOVE 100,000 pCi/L

LIMIT OF GROUNDWATER WITH TRITIUM ABOVE THE NEW JERSEY GROUNDWATER QUALITY CRITERION (20,000 pCi/L)

The underground plume faded as contaminated water was pumped out.

Source: Arcadis, *Groundwater Tritium Results,* 10/21/2005

Source: Arcadis, *Groundwater Tritium Results,* 05/24/2007



Millions of gallons of water extracted from the ground around Salem Unit 1 to recover nearly 3 ½ curies of leaked tritium.

Source: PSEG Nuclear, LLC, *Remedial Action Progress Report, First Quarter 2014, Salem Generating Station, September 22, 2014.* (ML15030A230)

* For disclosure, the author worked as a consultant in the licensing section in the first half of 1996

Was the contaminated water pumped out of the ground at Salem transported to Idaho for burial?

Nope.

Shipped to Iowa?

Nope.

Traded to Vermont for maple syrup?

Nope.

Was the contaminated water evaporated and as Bob Dylan sang, “blowin’ in the wind?

Nope.

"Batch releases are defined as:

- ***For Salem, FRAC Tank releases from the groundwater Remediation Project, releases from the Service Water Drums which are collected and disposed via the Non-Radwaste Basin, Waste Monitor Holdup Tanks and the Chemical Volume Control System (CVCS) Monitor Tanks. During the period of record, all batch liquid wastes from the Chemical Drain Tank and Laundry and Hot Shower Tanks C were routed to Waste Monitor Holdup Tanks for monitoring prior to release. For process flexibility of liquid effluents, the Salem Unit 1 and 2 Liquid Radwaste System is cross-connected."***
  [underlining added for emphasis]

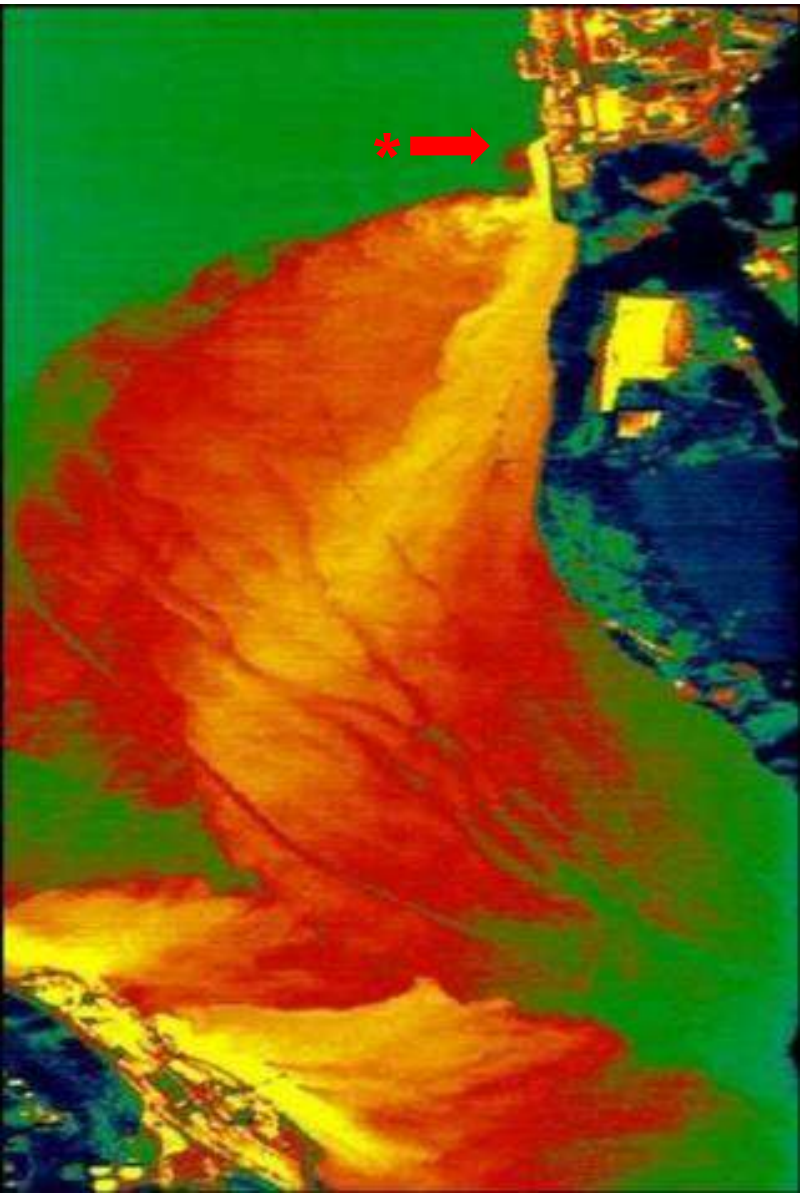
Source: PSEG Nuclear, LLC, *2005 Annual Radioactive Efflient Release Report for the Salem and Hope Ceek Generating Stations,* May 2006. (ML061290341)

	Salem Unit 1		Salem Unit 2	
	Batch Releases Tritium, curies	Batch Dilution Flow, gallons	Batch Releases Tritium, Curies	Batch Dilution Flow, gallons
2005	336.5	38,600,970,000	199.5	29,270,627,000
2006	701.1	83,152,520,000	642.8	57,605,660,000
2007	771.0	146,520,936,000	451.2	91,548,642,000
2008	424.0	223,507,586,000	266.8	174,600,162,000
2009	618.9	304,782,828,000	490.4	296,542,832,000
2010	962.0	404,799,186,000	729.1	403,284,858,000
2011	842.0	504,558,150,000	559.0	478,372,572,000
2012	1,193.7	619,902,154,000	1,060.9	606,898,517,760
2013	364.0	718,328,862,000	276.4	666,162,569,040

The contaminated water leaked from the Unit 1 spent fuel pool into the ground was extracted out of the ground and then released in batches to the Delaware River.

The Indian Point nuclear plant in New York was twice as bad as the Salem nuclear plant, at least in terms of number of leaking spent fuel pools.

The Unit 1 and Unit 2 spent fuel pools at Indian Point have leaked radioactively contaminated water into the ground.



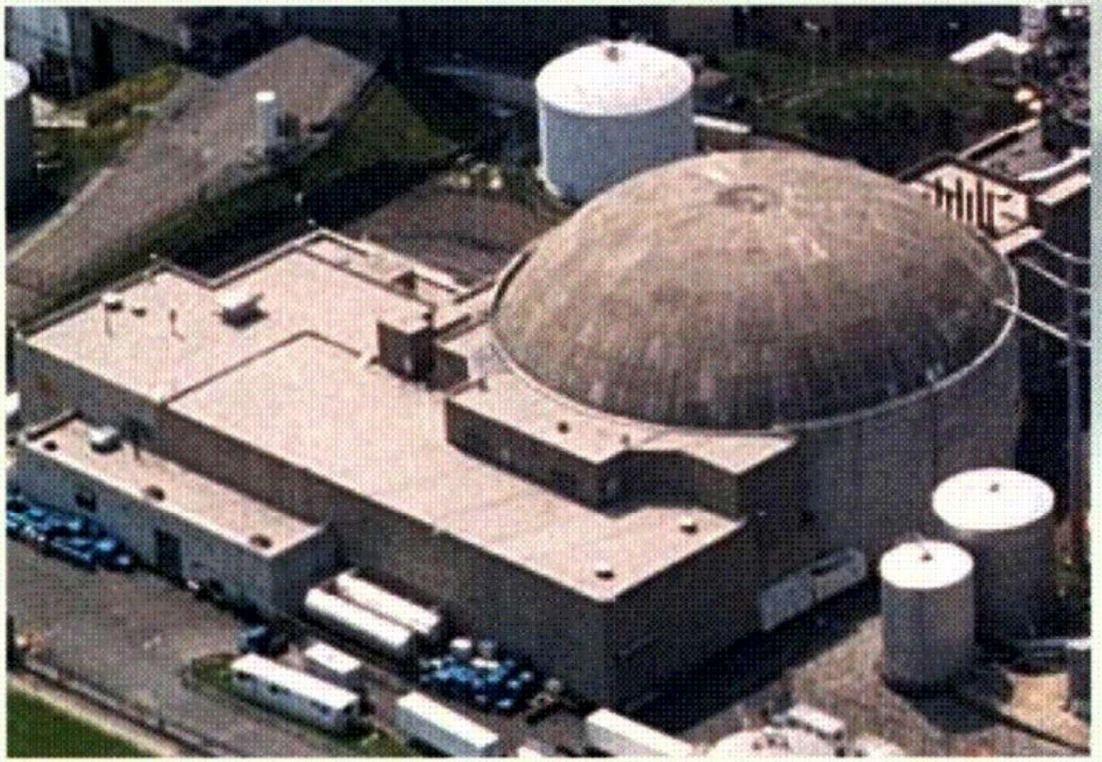
1990s (Unit 1) 2005 (Unit 2)

Leaking spent fuel pools at the Indian Point nuclear plant in New York.

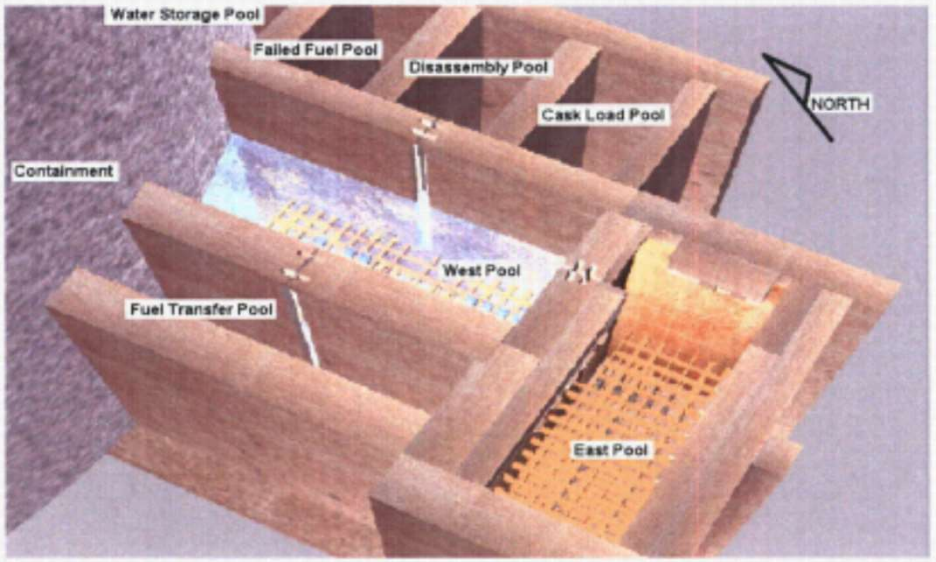
The red and yellow plume in the Hudson River emanating from Indian Point does not reflect consequences from the leaking spent fuel pool(s). It shows the effect from the discharge of water drawn from the river being returned to the river after being warmed passing through the plant.

* **For disclosure, the author worked as a consultant in the corporate engineering section in White Plains from September 1992 until September 1995, accompanied Rep. Sue Kelly on a tour of Indian Point on January 30, 2006, and was appointed to the Decommissioning Oversight Board in May 2021.**

UNIT 1 SPENT FUEL POOL



Samples collected adjacent to the Unit 1 spent fuel pool detected strontium-90, a fission product isotope that is found in the Unit 1 spent fuel pool water. While the levels of Sr-90 are low, Entergy expanded the well monitoring program to help characterize Sr-90. Entergy also installed a special demineralizer system to remove Sr-90 and other radioactive isotopes from the Unit 1 spent fuel pool water. Early results have shown this technique to be an effective means of limiting the release of Sr-90 to the groundwater.

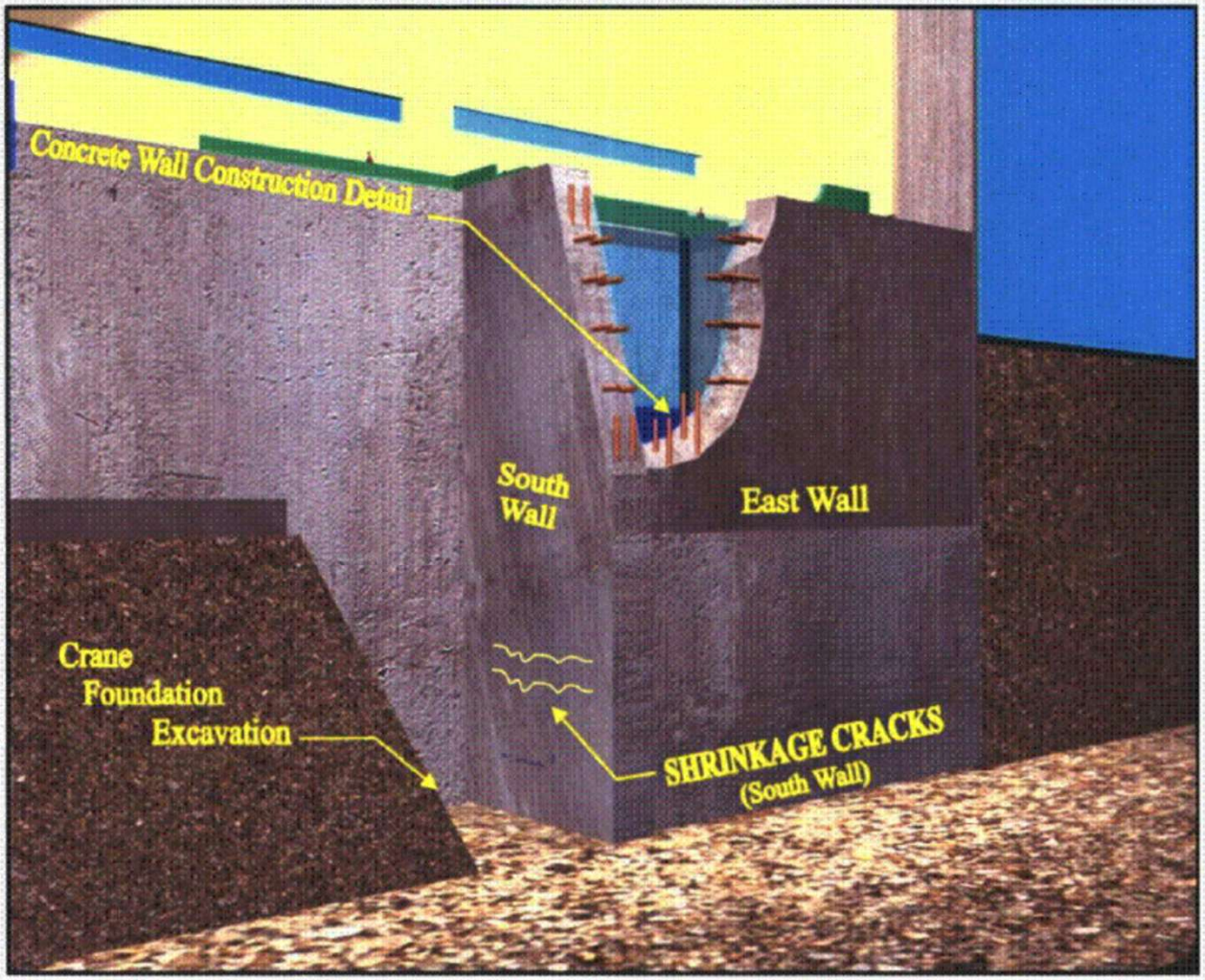


UNIT 1 FUEL POOL COMPLEX

The Unit 1 spent fuel pool was actually an assembly of several volumes that could be cross-connected or isolated as necessary to support fuel handling and storage.

Source: Entergy brochure, *Indian Point Groundwater Investigation,* October 2006.

The Unit 2 spent fuel pool walls were found to be leaking water into the ground.

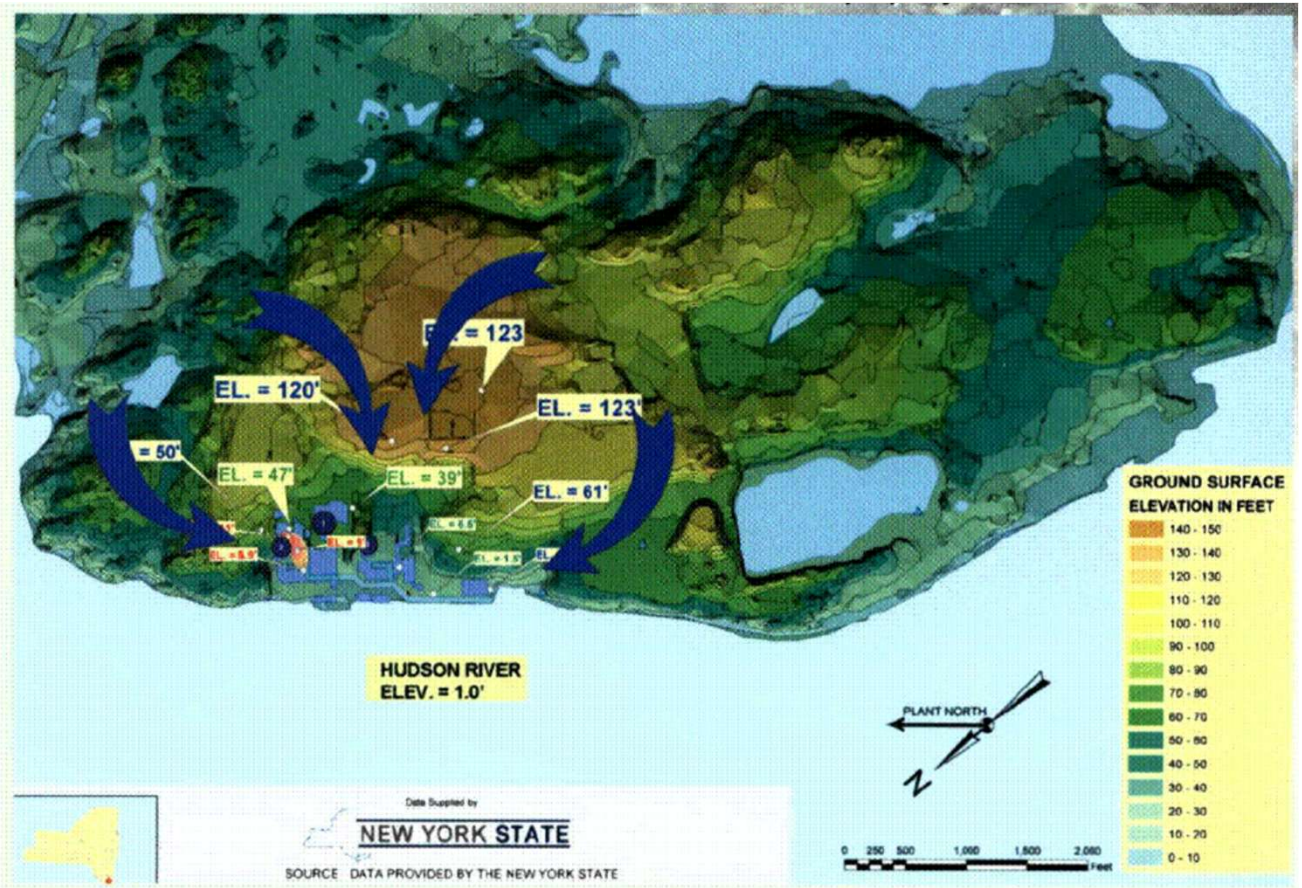


UNIT 2 SFP SHRINKAGE CRACKS IDENTIFIED IN SEPTEMBER 2005

Source: GZA Environmental, Inc., *Hydrogeologic Site Investigation Report Indian Point Energy Center,* January 7, 2008. (ML080320540)

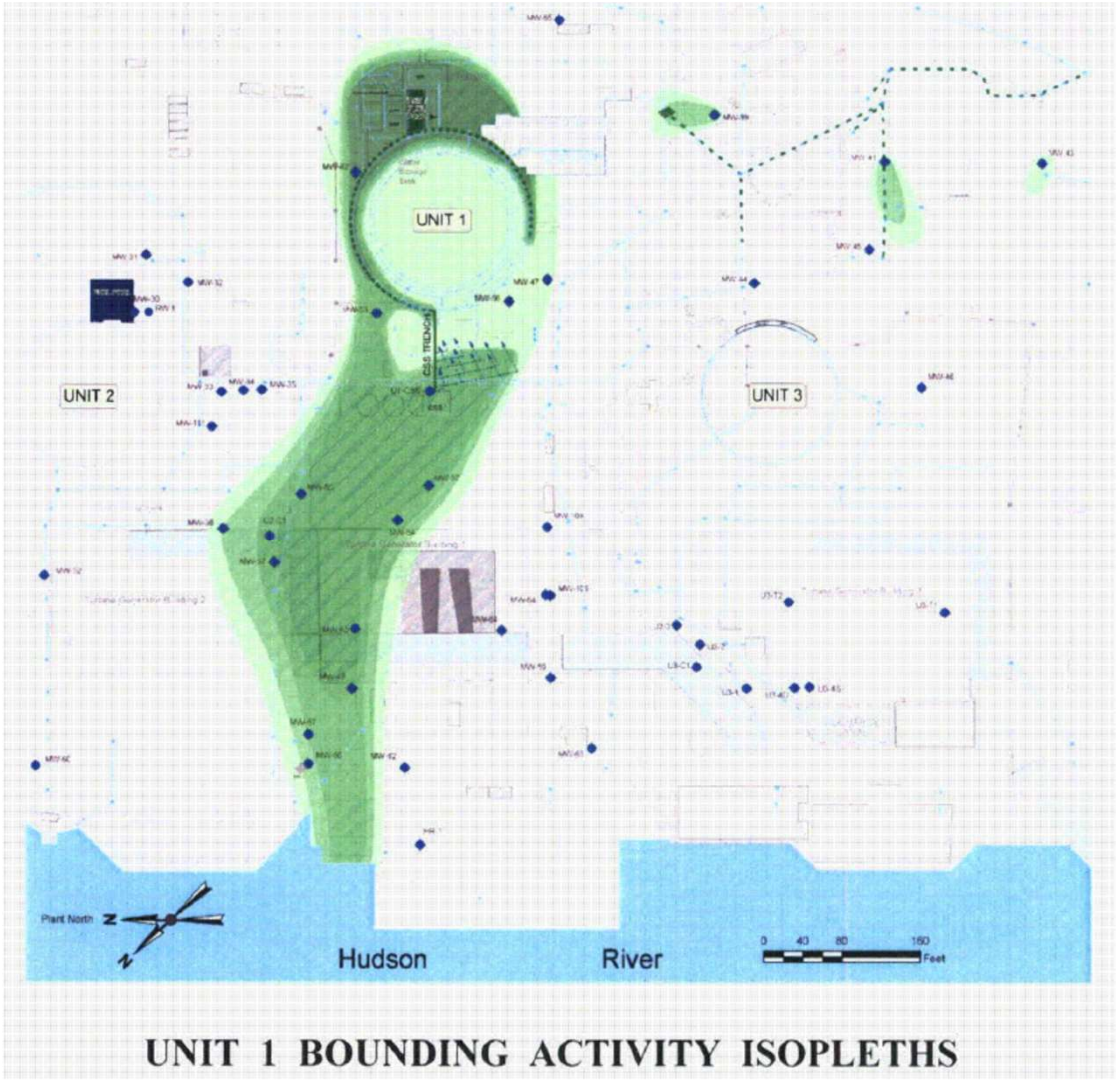
The consulting firm retained by Entergy found that the geology of the Indian Point site transported leaked water underground to the Hudson River rather than to inland areas.

The computer modeling results were confirmed by samples taken from many monitoring wells drilled at the site.



Entergy's hydrology consultants have reviewed well monitoring results, existing site drawings and previous groundwater studies and developed a conceptual model of how water flows on site. As shown by the blue arrows, groundwater flows inward toward the site from surrounding areas and once onsite, flows generally west towards the discharge canal and river.

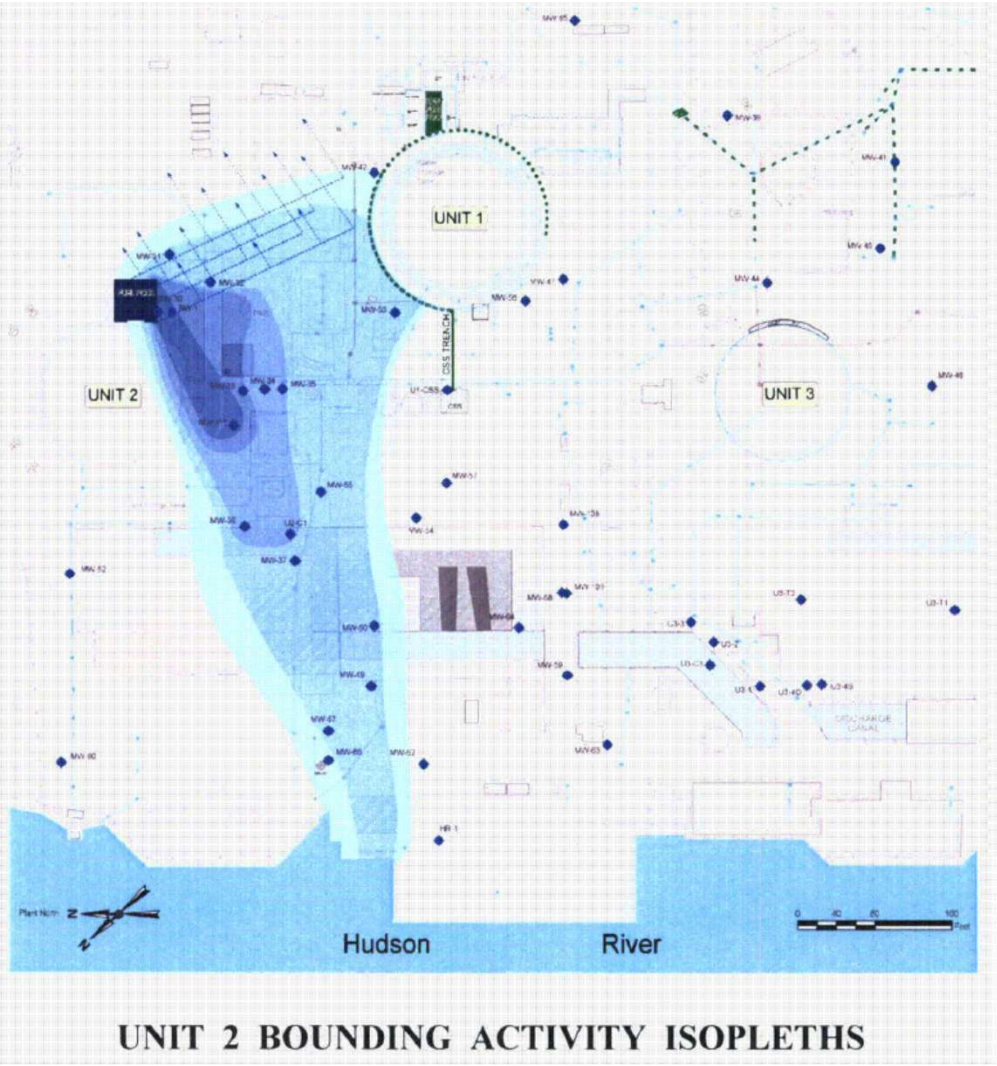
Source: Entergy brochure, *Indian Point Groundwater Investigation,* October 2006.



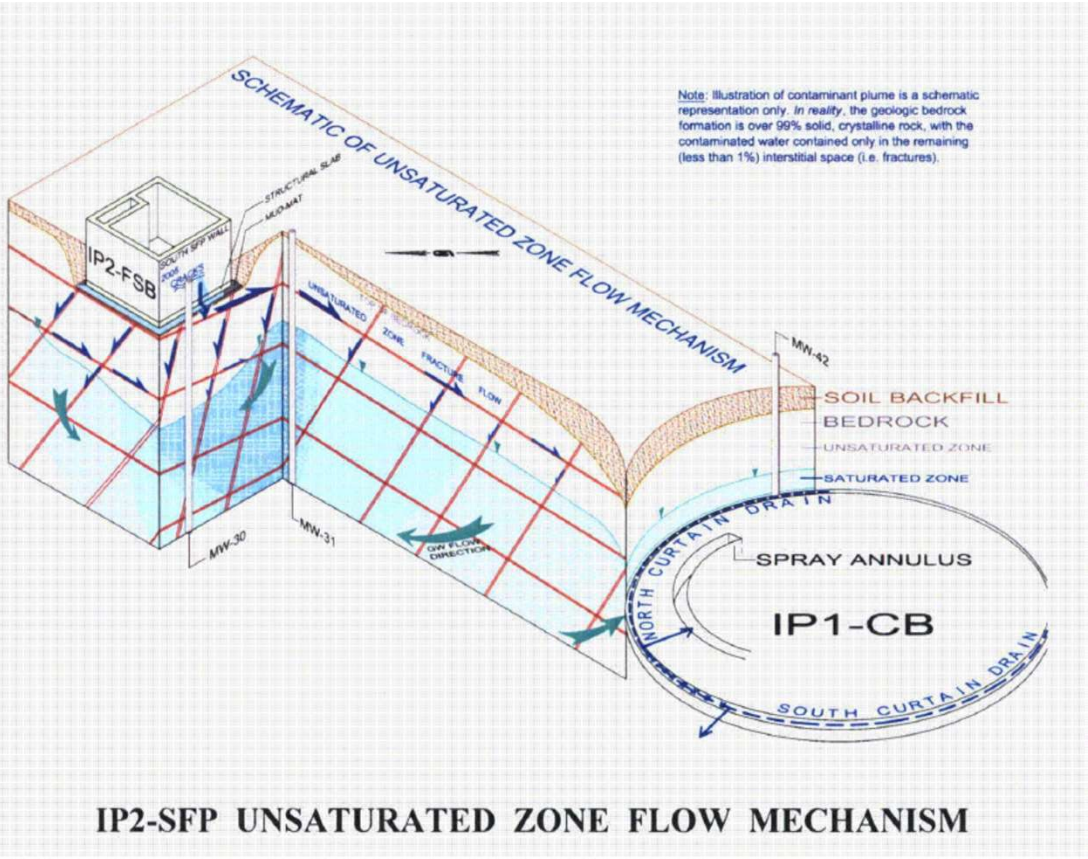
UNIT 1 BOUNDING ACTIVITY ISOPLETHS

Samples from the monitoring wells allowed the plume of contaminated water underground to be plotted for the Unit 1 spent fuel pool source.

Source: GZA Environmental, Inc., *Hydrogeologic Site Investigation Report Indian Point Energy Center,* January 7, 2008. (ML080320540)



UNIT 2 BOUNDING ACTIVITY ISOPLETHS



IP2-SFP UNSATURATED ZONE FLOW MECHANISM

Unit 2, too.

Source: GZA Environmental, Inc., *Hydrogeologic Site Investigation Report Indian Point Energy Center,* January 7, 2008. (ML080320540)

11.0 RECOMMENDATIONS

Based upon the comprehensive groundwater investigation and other work performed by Entergy, GZA recommends the following:

1. Repair the identified Unit 2 Transfer Canal liner weld imperfection (completed mid December 2007); **R1 ✓**
2. Continue source term reduction in the Unit 1 pool via the installed demineralization system;
3. Remove the remaining Unit 1 fuel and drain the pools; and
4. Implement long term monitoring consistent with monitored natural attenuation, property boundary monitoring, future potential leak identification, and support of ongoing dose assessment.

One by one, the recommended remedial measures for the Unit 1 and 2 leaking spent fuel pools were implemented.

Source: GZA Environmental, Inc., *Hydrogeologic Site Investigation Report Indian Point Energy Center,* January 7, 2008. (ML080320540)

R3 ✓

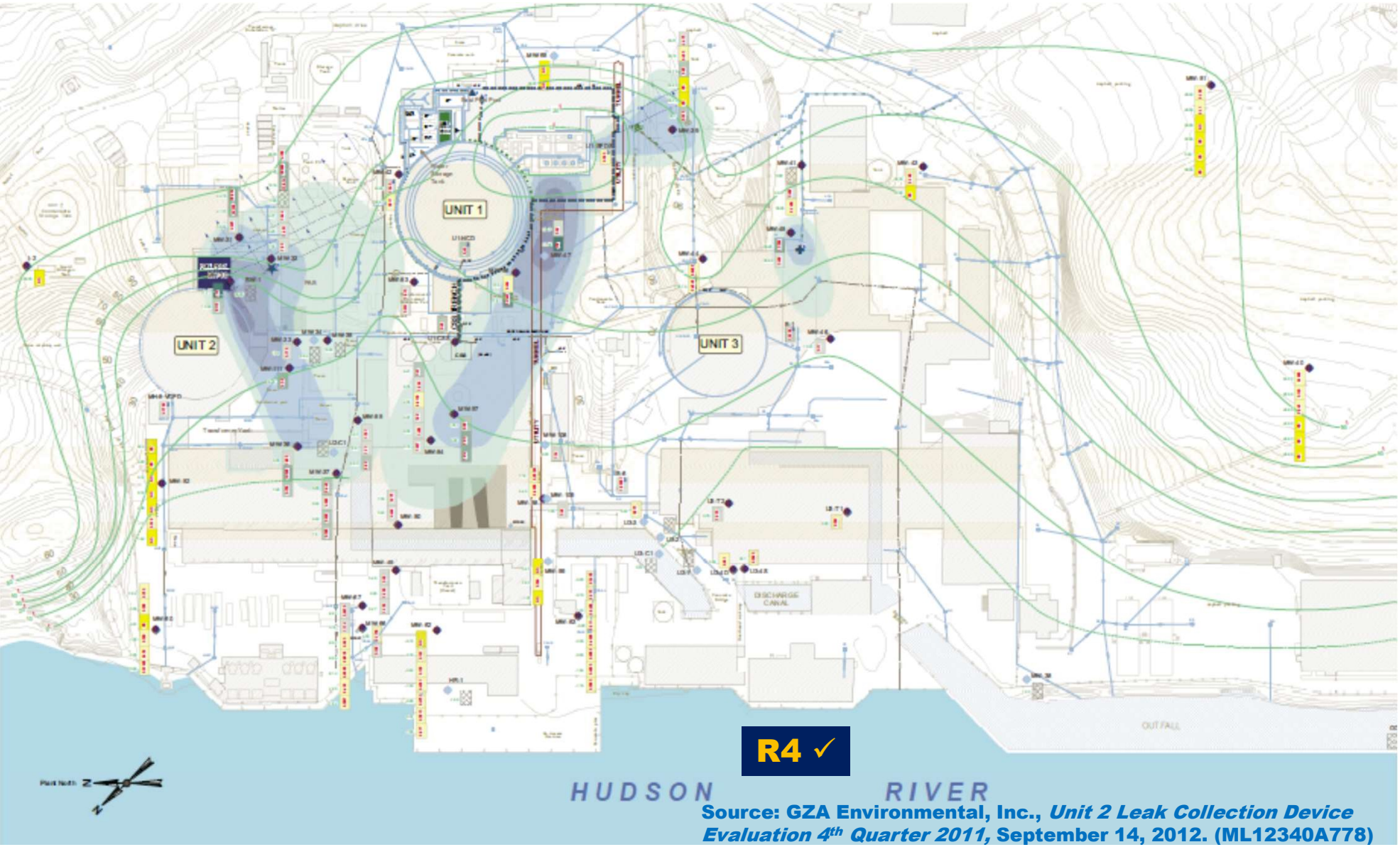
Between July 21, 2008 and September 19, 2008, the spent fuel assemblies were transferred from the Unit 1 spent fuel pool into dry storage onsite.

Draining water from the Unit 1 spent fuel pool was completed on October 15, 2008.

Unit	Date	Cask No.	No. Fuel Assemblies	Cask Type	Cumulative Casks	Cumulative Fuel Assemblies	Source
2	1/11/2008	1	32	HI-STORM 100	1	32	ML080440312
2	1/22/2008	2	32	HI-STORM 100	2	64	ML080440312
2	2/2/2008	3	32	HI-STORM 100	3	96	ML080440312
1	7/21/2008	1	32	HI-STORM 100	4	128	ML082410420
1	8/13/2008	2	32	HI-STORM 100	5	160	ML082410420
1	9/7/2008	3	32	HI-STORM 100	6	192	ML082840582
1	9/19/2008	4	32	HI-STORM 100	7	224	ML082840582
1	9/19/2008	5	32	HI-STORM 100	8	256	ML082840582
2	9/11/2009	4	32	HI-STORM 100	9	288	ML092870622
2	9/29/2009	5	32	HI-STORM 100	10	320	ML092870622
2	11/9/2009	6	32	HI-STORM 100	11	352	ML093440150
2	12/14/2009	7	32	HI-STORM 100	12	384	ML100260395
2	7/22/2010	8	32	HI-STORM 100	13	416	ML102371183
2	8/20/2010	9	32	HI-STORM 100	14	448	ML102670190
2	12/16/2010	10	32	HI-STORM 100	15	480	ML110260099
2	7/6/2011	11	32	HI-STORM 100	16	512	ML11224A019
2	7/28/2011	12	32	HI-STORM 100	17	544	ML11224A019
2	9/7/2011	13	32	HI-STORM 100	18	576	ML11265A233
2	9/28/2011	14	32	HI-STORM 100	19	608	ML11306A091
3	11/23/2012	1	32	HI-STORM 100	20	640	ML13002A075
3	12/1/2012	2	32	HI-STORM 100	21	672	ML13002A075
3	7/31/2013	4	32	HI-STORM 100	22	704	ML13225A013
3	8/14/2013	5	32	HI-STORM 100	23	736	ML13259A057
3	8/29/2013	6	32	HI-STORM 100	24	768	ML13259A057
2	9/25/2013	15	32	HI-STORM 100	25	800	ML13298A023
3	11/5/2014	7	32	HI-STORM 100	26	832	ML14337A092
3	11/20/2014	8	32	HI-STORM 100	27	864	ML14365A094
3	12/4/2014	9	32	HI-STORM 100	28	896	ML15008A030
3	12/10/2102	3	32	HI-STORM 100	29	928	ML13002A075

Chronology of Cask Loadings at Indian Point

Source: Entergy to NRC email, *Indian Point 1*, November 5, 2008. (ML090570830)



R4 ✓

Source: GZA Environmental, Inc., *Unit 2 Leak Collection Device Evaluation 4th Quarter 2011,* September 14, 2012. (ML12340A778)

	Fission and Activation Products	Tritium	Dissolved and Entained Gases	Gross Alpha	Total Curies
	Curies	Curies	Curies	Curies	
2005	0.075	1272.000	0.075	0.000	1272.150
2006	0.059	1558.000	**0.382**	0.000	1558.441
2007	0.054	1468.000	0.040	0.000	1468.094
2008	0.069	667.021	0.038	0.000	667.127
2009	0.063	1859.000	0.009	0.000	1859.071
2010	0.067	1390.000	0.001	0.000	1390.067
2011	0.056	1907.000	0.025	0.000	1907.081
2012	0.047	1989.000	0.002	0.000	1989.050
2013	0.076	**2045.000**	0.003	0.000	**2045.079**
2014	0.040	640.000	0.000	0.000	640.041
2015	0.077	1972.000	0.012	0.000	1972.089
2016	**0.138**	1083.000	0.000	0.000	1083.138
2017	0.080	1422.000	0.004	0.000	1422.084
2018	0.090	1358.000	0.001	0.000	1358.090
2019	0.039	832.000	0.001	0.000	832.040

This table shows the amounts of radioactivity in water discharged to the Hudson River. Tritium forms the primary constituent of radioactivity releases. When tritium forms part of a water molecule, it is virtually impossible to remove from water by filters, polishers, and demineralizers. Maximum amounts of each category shown in enlarged boldface type.

Source: Owner's annual effluent reports to the NRC (e.g. ML061240373)

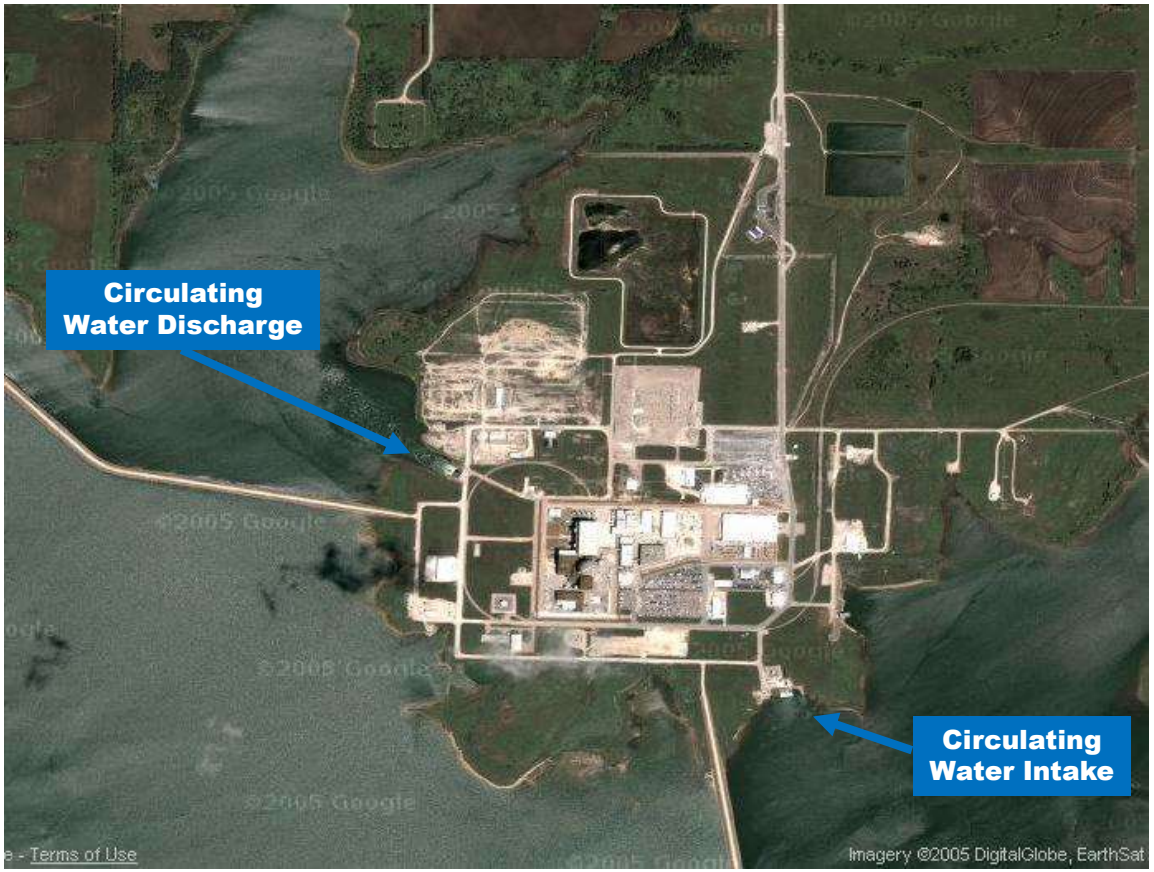
	Total Whole Body Dose	Total Body Dose Limit (40 CFR 190)	Fraction of Limit
	millrem	millrem	
2005	0.001256	25	0.0050%
2006	0.001007	25	0.0040%
2007	0.000855	25	0.0034%
2008	0.000767	25	0.0031%
2009	0.001149	25	0.0046%
2010	0.000688	25	0.0028%
2011	0.000748	25	0.0030%
2012	0.000576	25	0.0023%
2013	0.001375	25	0.0055%
2014	0.0004589	25	0.0018%
2015	0.001247	25	0.0050%
2016	0.001091	25	0.0044%
2017	0.000784	25	0.0031%
2018	**0.001947**	25	**0.0078%**
2019	0.0005892	25	0.0024%

This table shows the total body dose to the public from the radioactivity in water discharged to the Hudson River. The doses are small fractions of the federal limit. Maximum amounts of each category shown in enlarged boldface type.

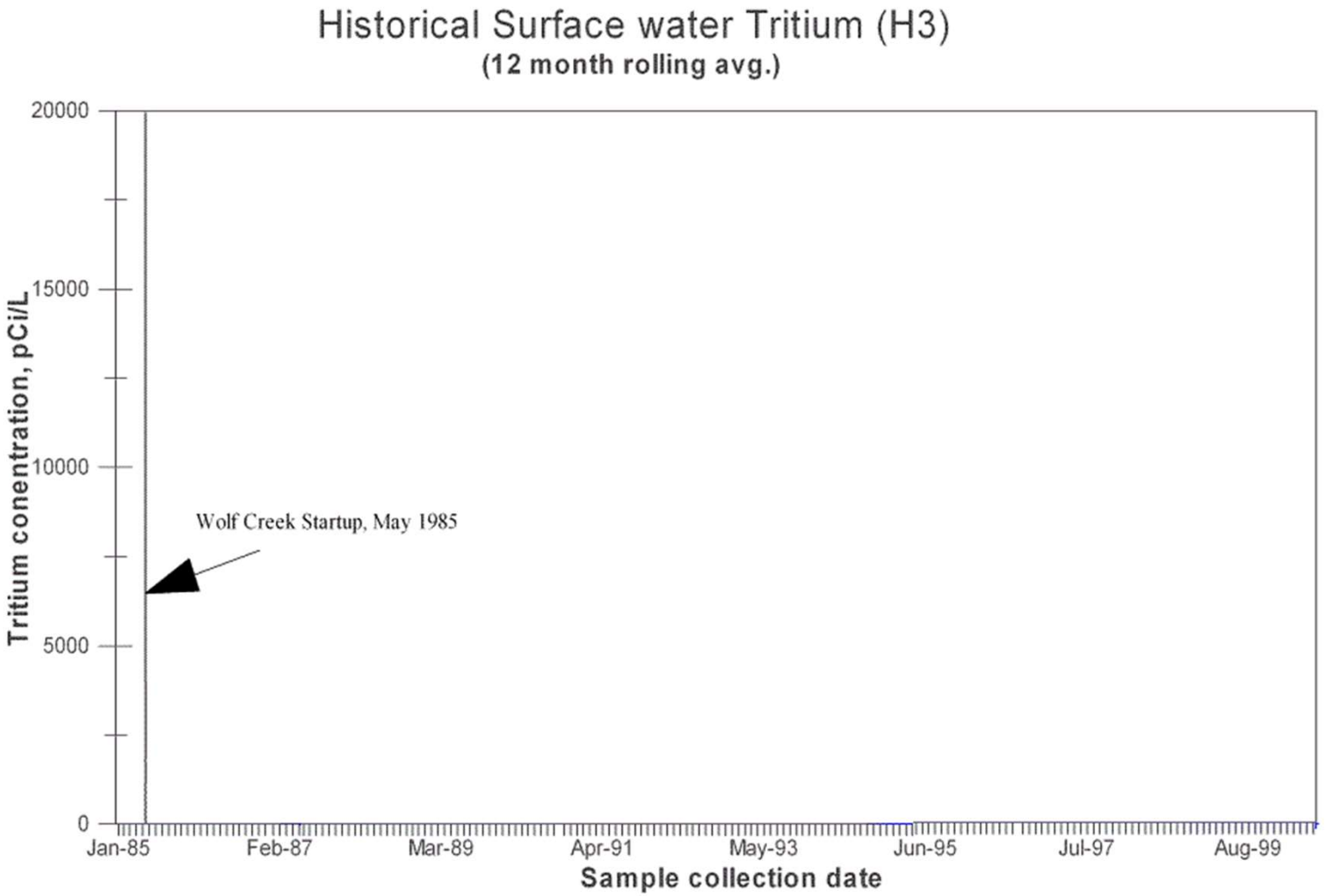
Source: Owner's annual effluent reports to the NRC (e.g. ML061240373)

As far as is known, the spent fuel pool at the Wolf Creek nuclear plant in Kansas is not now leaking and has not leaked in the past. But its repository for discharged water may suggest that it is not a grand place for spent fuel pool water to go.

The Wolf Creek nuclear plant located north of Burlington, Kansas features one Westinghouse pressurized water reactor (PWR).



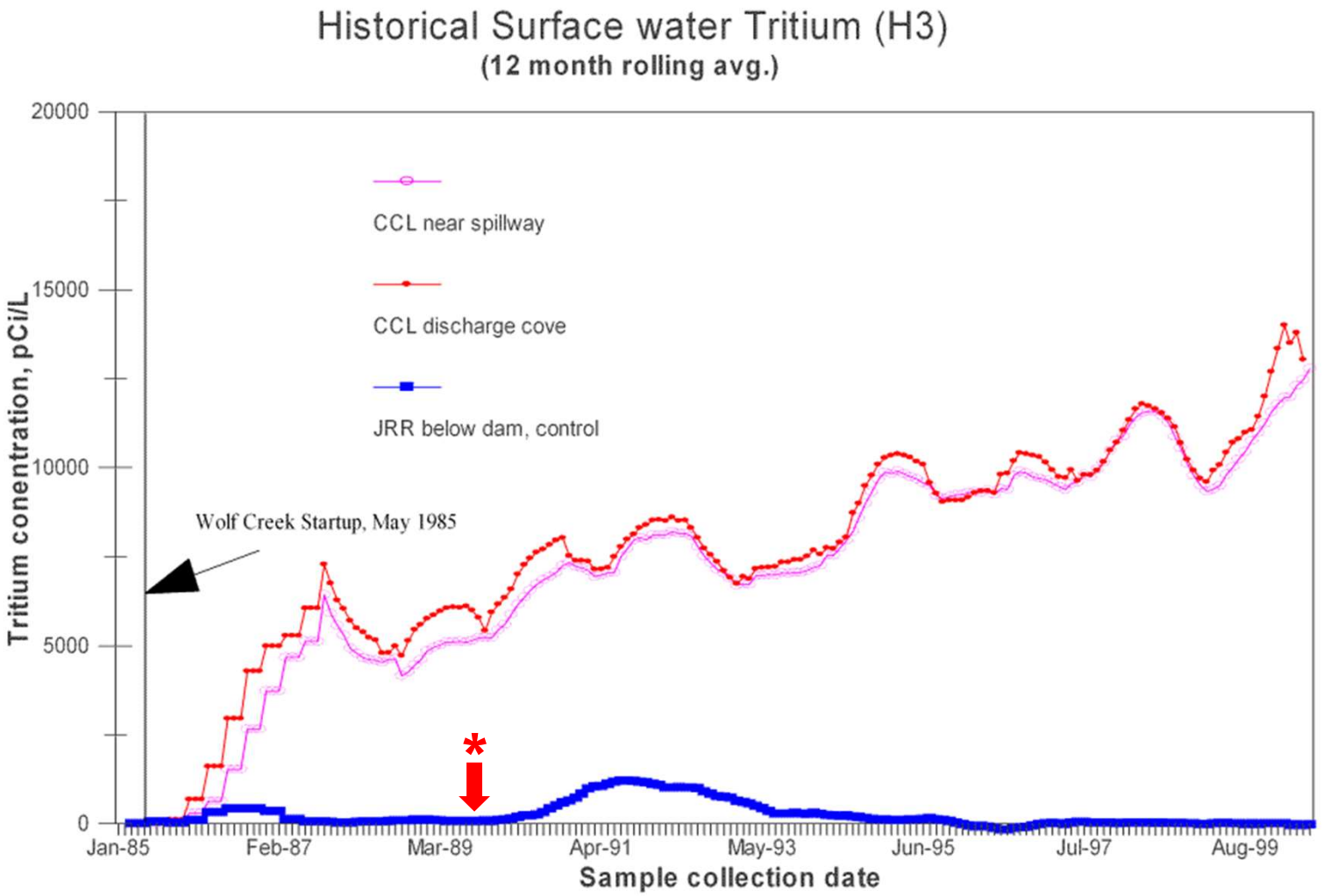
The circulating water intake structure contains pumps pulling cooling water from Coffey County Lake and circulating through the plant to cool equipment with the warmed water discharged back into the lake.



Wolf Creek started up in 1985.

...speaking of starting up

Source: Kansas Department of Health and Environment, Wolf Creek Generating Station Environmental Radiation Surveillance Report, July 1999 – June 2000

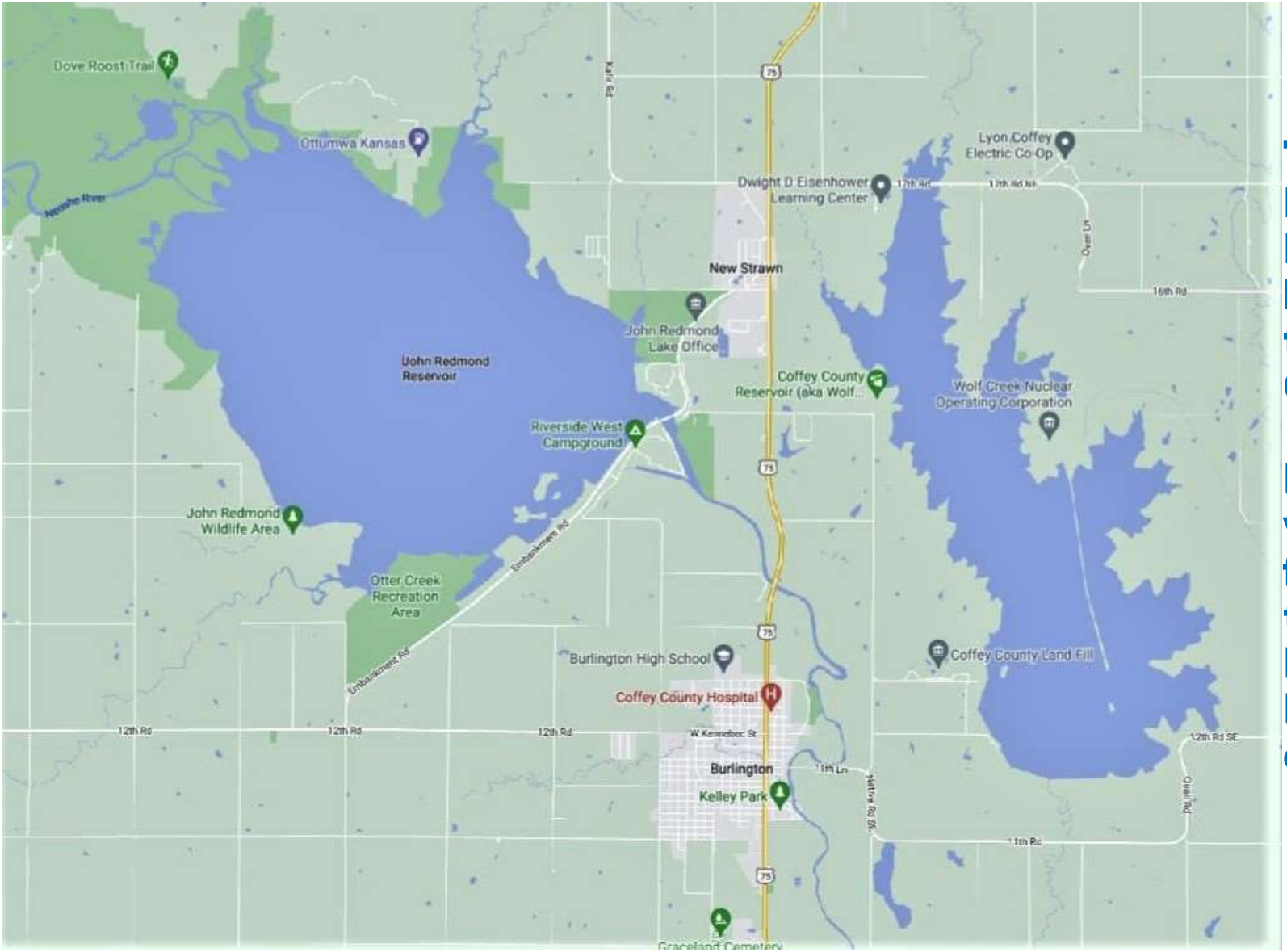


Tritium levels also started up in 1985, steadily moving towards the 20,000 picocurie per liter (pCi/L) EPA drinking water limit.

Levels in the John Redmond Reservoir (JRR) remained low.

Source: Kansas Department of Health and Environment, Wolf Creek Generating Station Environmental Radiation Surveillance Report, July 1999 – June 2000

*** For disclosure, the author worked as a consultant in the licensing section in the summer of 1989**



The larger John Redmond Reservoir is located west of the Coffey County Lake.

By not getting water discharged from Wolf Creek, the John Redmond Reservoir stayed clean.

Readers hardy enough to have waded through to this slide may have noticed a common theme across the nuclear plants covered thus far – the author worked at all of them (not at the same time.)

Lest the author be considered the cause of or jinx for the contaminated water released from these plants, recall a line uttered by actor Clint Eastwood in one, maybe all, of his Dirty Harry roles: "*A man's got to know his limitations*."

Even if complicit in the aforementioned events, the statute of limitations has long since tolled.

Source: eBay

The Vermont Yankee nuclear plant in – wait for it – Vermont showed a way to dispose of spent fuel pool water without discharging it into the nearby lake, river or ocean. It was transported to Idaho.

On January 14, 2016, Vermont Yankee's owner asked the NRC for an exemption from federal regulations so it could transport about 200,000 gallons of radioactively contaminated water to the US Ecology, Inc. disposal site near Grand View, Idaho.

The water was stored in the torus and being continuously circulated through a treatment system to minimize suspended solids. Analysis of a sample of the torus water showed it to contain:

Cobalt-60	**0.78 picocuries/liter**
Cesium-137	**0.33 picocuries/liter**
Tritium	**1,870 picocuries/liter**
Zinc-65	**0.24 picocuries/liter**

Source: Entergy Nuclear Operations, Inc. to US Nuclear Regulatory Commission, *10 CFR 20.2002 Request for Alternate Waste Disposal at US Ecology Idaho,* January 14, 2016. (ML16029A071)

*** For disclosure, the author was appointed in September 2008 to the Oversight Panel for the State of Vermont's Reliability Assessment of Vermont Yankee**

On June 20, 2017, the NRC granted Vermont Yankee's request for an exemption from federal regulations so it could transport about 200,000 gallons of radioactively contaminated water in tanker trucks (5,000 gallons each) to the US Ecology, Inc. disposal site near Grand View, Idaho.

The NRC applied a standard of "not more than a few millirem per year" dose to any member of the public. The dose to the truck drivers was estimated to be 3.13 millirem per year and considered to bound any dose a member of the public would receive. No leaks or spills at the plant, at the disposal site, or on the roads was considered.

Source: Nuclear Regulatory Commission, *Vermont Yankee Nuclear Power Station – Request for 10 CFR 20.2002 Alternate Disposal at US Ecology Idaho,* June 20, 2017. (ML17087A147)

On May 20, 2020, Vermont Yankee's owner asked the NRC for another exemption from federal regulations so it could transport about 2,000,000 gallons of radioactively contaminated water to the US Ecology, Inc. disposal site near Grand View, Idaho.

Analysis of a sample of the water showed it to contain:

Cobalt-60	**437,000 picocuries/liter**
Cesium-137	**49,300 picocuries/liter**
Tritium	**1,220,000 picocuries/liter**

Source: NorthStar Nuclear Decommissioning Co., LLC. to Nuclear Regulatory Commission, *10 CFR 20.2002 Request for Alternate Waste Disposal at US Ecology Idaho,* May 20, 2020. (ML20157A123)

On May 7, 2021, the NRC granted Vermont Yankee's request for an exemption from federal regulations so it could transport about 2,000,000 gallons of radioactively contaminated water in railcars (20,000 gallons each) to the US Ecology, Inc. disposal site near Grand View, Idaho. The water would come from the reactor cavity, spent fuel pool, and separator pit.

The NRC considered the potential radiation doses to railway workers, tanker truck drivers, landfill workers during the projected 101 shipments and found the maximum dose could be 4.79 millirem per year to truckers.

The 4.79 millirem trucker annual dose is 2,460 times higher than the highest annual dose to a member of the public from water discharged to the Hudson River between 2005 and 2019.

Source: Nuclear Regulatory Commission, *Vermont Yankee Nuclear Power Station – Request for 10 CFR 20.2002 Alternate Disposal at US Ecology Idaho,* May 7, 2021. (ML21082A115)

The NRC stated "*The NRC staff notes that the evaluation of the transport dose to the public is not required per the most recent revision to the "Guidance for the Reviews of Proposed Disposal Procedures and Transfers of Radioactive Material under 10 CFR 20.2002 and 10 CFR 40.13(a)" ... and the NRC staff does not evaluate doses from the disposal of radioactive material while it is in transit for disposal therefore did not review the transport dose during their review of this 20.2002 request.*"

Table 4 Projected USEI Worker Dose*

Job Function	Annual Dose mrem/yr (mSv/yr)
Gondola Railcar Surveyor	1.83 (0.0183)
Tanker Truck Drivers	4.90 (0.0490)
Treatment Workers	4.79 (0.0479)
Treatment Plant Truck Driver	1.60 (0.0160)
Landfill Cell Operator	4.53 (0.0453)

*The evaluation of the transport dose to the public is not required under current NRC guidance for the review of disposal of radioactive material under 10 CFR 20.2002.

Thanks NRC, literally for nothing! Easiest way to overlook a safety problem is to not look for one.

Source: Nuclear Regulatory Commission, *Vermont Yankee Nuclear Power Station – Request for 10 CFR 20.2002 Alternate Disposal at US Ecology Idaho,* May 7, 2021. (ML21082A115)

It's not like problems cannot be found. Here's an abridged listing of handling and transport events found in – wait for it – NRC's public document room:

Event Date	Site Name	City	State	Event Description
19630808	Big Rock Point	Charlevoix	MI	Radioactively contaminated water leaked from a flange on the outdoor waste hold tank located to the west of the turbine building. It is likely that the contaminated water entered the ground below the tanks.
19630918	Yankee Rowe	Rowe	MA	Approximately 10 gallons of radioactively contaminated water spilled onto the ground when a one-half inch sampling valve was inadvertently left open while filling the shield tank cavity from the safety injection tank. After cleanup, the residual contamination level was measured to be 70 to 100 millirem per hour at one inch off the pavement.
19730424	Oyster Creek	Forked River	NJ	About 100 gallons of radioactively contaminated water leaked into the ground from a storage tank truck.
19730910	Oconee	Seneca	SC	Approximately 20 gallons of radioactively contaminated water spilled onto the ground when a Chem-Nuclear tank truck overflowed as waste from the B miscellaneous waste hold-up tank was being transferrred.
19731220	Oyster Creek	Forked River	NJ	About 3,400 gallons of radioactively contaminated water leaked into the ground after the drain line from a temporary storage tank froze and cracked.
19740317	Dresden	Morris	IL	Radioactively contaminated water was spilled when a valve that was supposed to divert flow to an empty tank when the aligned tank was filled to capacity failed. As a result, the tank was overfilled.
19741218	Oconee	Seneca	SC	Approximately 50 gallons of radioactively contaminated water spilled onto the ground when a Chem-Nuclear tank truck overflowed.
19750611	Pilgrim	Plymouth	MA	About 150 gallons of radioactively contaminated water overflowed a disposable resin cask in a truch and spilled onto the ground outside the radwaste building.
19760610	Pilgrim	Plymouth	MA	Approximately 150 gallons of radioactively contaminated water overflowed a disposable resin cask on a truck and spilled onto the ground outside the radwaste building. About 400 square feet were contaminated. Workers confined the spill with vermiculite and commenced cleanup.
19760720	Vermont Yankee	Vernon	VT	Approximately 83,000 gallons of radioactively contaminated water overflowed the condensate storage tank into the storm drain system to the Connecticut River over a two-day period.
19770802	Pilgrim	Plymouth	MA	While spent fuel pool resin was being transferred to the spent resin storage tank, radioactively contaminated water flowed through an open vent valve onto the pavement outside the radwaste truck lock door. The spilled water was mopped up and the contaminated asphalt paved over.
19771009	Salem	Salem	NJ	Approximately 600 gallons of radioactively contaminated water were inadvertently pumped from a liquid waste tank into a circulating water discharge pipe instead of to a tanker truck.

* For disclosure, the author worked for the NRC as a reactor technology instructor from March 2009 to March 2010

Event Date	Site Name	City	State	Event Description
19780430	Crystal River	Red Level	FL	The NRC reported about a spill of radioactively contaminated resin. Workers were transferring the resin from a holdup tank inside the auxiliary building to a shielded shipping cask outside. All of the hoses were metal-braided and all of the piping was steel except for a polyvinylchloride tee inside the trailer. When level in the cask was sensed high, an automatic shut-off valve closed. The ensuing pressure surge caused the PVC tee to break. Resin spilled from the broken tee into the trailer's sump. Bolted seams in the sump leaked resin onto the asphalt pavement under the trailer. The resin slurry flowed into a nearby storm drain.
19790201	Zion	Zion	IL	During the transfer of the 2A mixed bed to an HN-200 cask, the cask was overfilled and approximately 25 gallons of water and resin flowed into the ground.
19790330	Zion	Zion	IL	During the transfer of resin to a cask, the cask was overfilled and approximately 25 gallons of water and resin flowed into the ground. A failed high liquid level alarm and a frozen overflow vent line factored into the event.
19790611	Turkey Point	Florida City	FL	Approximately 900 gallons of radioactively contaminated water overflowed a waste processing tank due to an operator error in aligning valves. The auxiliary building floor drain backed up to the onsite storm drain. The drain system discharged the radioactively contaminated water to an onsite underground tile bed.
19790612	Indian Point	Buchanan	NY	About 10 gallons of radioactively contaminated water was spilled when a hose failed during backflushing of a shipping cask for spent resin.
19790828	Turkey Point	Florida City	FL	Approximately 3,000 gallons of radioactively contaminated water overflowed the refueling water storage tank and spilled onto the ground. It was estimated the spilled water contained 1.091 curies.
19791215	Zion	Zion	IL	During the transfer of resin to a cask, the cask was overfilled and approximately 25 gallons of water and resin flowed into the ground. A failed high liquid level alarm and a frozen overflow vent line factored into the event. The outside air temperature a
19800716	Oconee	Seneca	SC	Approximately 5 gallons of radioactively contaminated water spilled onto the ground from a liner in the mobile solidification area south of the interim radwaste building as the liner was being filled. The leak was through an inspection hole in the cask holding the liner.
19800806	Yankee Rowe	Rowe	MA	As workers were pumping resin into a disposal cask, radioactively contaminated water leaked from the transfer hose. A 15-foot by 20-foot area in the yard was contaminated. Some of the contaminated asphalt was removed and shipped to a licensed low-level radwaste dump.
19800913	Palisades	South Haven	MI	A fork lift transporting a canister of radioactive waste hit a pot hole. About two gallons of radioactively containment liquid spilled from the canister when it slipped from the forks. Workers removed the contaminated soil and placed it it waste barrels for disposal.
19810628	Indian Point	Buchanan	NY	About 45 gallons of radioactively contaminated water spilled when a resin cask was overfilled.

Event Date	Site Name	City	State	Event Description
19811027	H. B. Robinson	Hartsville	SC	Approximately 3,600 gallons of radiaoctively contaminated water leaked from a temporary tank holding chemical decontamination waste water and flowed into the site storm drain where it flowed on to the west settling pond.
19820119	Beaver Valley	Shippingport	PA	Approximately 500 gallons of radioactively contaminated water being transferred between waste tanks spilled onto the ground when the transfer pipe froze and cracked. A security guard on rounds noticed the leakage and notifed operators who took steps to stop the leaking.
19820317	Turkey Point	Florida City	FL	A valve lineup durign the transfer of radioactively contaminated water from the Unit 3 reactor cavity to the Unit 3 refueling water storage tank allowed ater to overfill the Unit 4 refueling water storage tank. About 11,000 gallons spilled onto the ground, flowed through storm drains into the intake canal.
19820709	Oconee	Seneca	SC	Radioactively contaminated water spilled into the ground near the Unit 3 solidificaiton area while a portable demineralizer was being filled.
19840913	Haddam Neck	Haddam Neck	CT	Radioactively contaminated water spilled when a resin liner was overfilled.
19870625	Haddam Neck	Haddam Neck	CT	An estimated 140,000 gallons of radioactively contaminated water leaked into the discharge canal after a truck struck the Primary Water Storage Tank.
19881116	Pilgrim	Plymouth	MA	Due to a valve inadvertently left open, 2,300 gallons of radioactively contaminated water spilled form a container of used filters on the process building floor. The water flowed outside the building towards the inner site boundary fence. About 1,000 cubic feet of gravel and earth were removed during the remediation effort.
19900822	Zion	Zion	IL	Approximately 200 gallons of radioactively contaminated water spilled from a vendor laundry trailer, contaminating an area of about 80-feet by 80-feet.
19910328	Palisades	South Haven	MI	As resin was being sluiced from tank T-104B to a resin storage cask, a clog pressurized and broke the transfer hose. About 20 cubic feet of resin spilled into the turbine building and onto the pavement outside. Workers decontaminated the pavement and turbine building floor.
19940507	Palisades	South Haven	MI	A truck transporting a box of contaminated soil hit a bump, causing the box to fall from the truck. The box broke open and deposited about half its contents onto the road near the south radwaste building.
19950819	St. Lucie	Hutchinson Island	FL	Approximately 11,250 gallons of radioactively contaminated water overflowed the primary water tank onto the ground and into storm drains. It was estimated that the leaked water contained 3.94 curies of tritium.
19970430	Sequoyah	Soddy-Daisy	TN	Approximately 3,000 gallons of radioactively contaminated water spilled from the modularized transfer demineralization system when a conductivity probe failed. An estimated 600 to 1,000 gallons flowed through the railroad bay door to the ground outside.
20001129	Oconee	Seneca	SC	Radioactively contaminated water spilled at the treatment storage disposal facility and contaminated some soil.

Event Date	Site Name	City	State	Event Description
20010831	LaSalle County	Seneca	IL	Radioactively contaminated water entered the ground when the Unit 2 cycled condensate storage tank overflowed.
20010920	St. Lucie	Hutchinson Island	FL	Approximately 83 gallons of radioactively contaminated water leaked onto the ground from a hose connected to waste monitor tank 1A.
20020208	St. Lucie	Hutchinson Island	FL	Approximately 15 gallons of radioactively contaminated water leaked onto the ground when a resin dewatering hose became disconnected from a floor drain. About five gallons reached the storm drains.
20040413	St. Lucie	Hutchinson Island	FL	Approximately 2,400 gallons of radioactively contaminated water overflowed the refueling water tank onto the ground and into the storm drain system.
20070621	Brunswick	Southport	NC	During the transfer of radioactively contaminated water from the Unit 1 suppression pool to the waste surge tank, about 2,500 to 3,000 gallons of water leaked onto the ground from a disassembled check valve on the drain line from the Unit 2 condensate storage tank to the waste storage tank. Some of the leaked water entered the storm drain system.
20071226	Edwin I. Hatch	Baxley	GA	An estimated 5,700 gallons of radioactively contaminated water leaked into the ground when recently installed piping to underground collection tank 1Y22N008A became separated. A sample of water from the leak had tritium concentrations of 24,900 picocuries per liter.
20080105	Browns Ferry	Decatur	AL	The condensate storage tank overflowed due to failed tank level instrumentation. The spilled water flowed into the sump in the condensate piping tunnel, triggering a high level alarm that prompted workers to initiate the search that discovered the overflow condition. Some of the spilled water may have permeated through the pipe tunnel into the ground.
20080204	McGuire	Cornelius	NC	The company reported that a leak in the final holdup pond allowed approximately 100,000 gallons of radioactively contaminated water to leak into the groundwater.
20100407	Browns Ferry	Decatur	AL	Approximately 1,000 gallons of radioactively contaminated water leaked from Condensate Storage Tank No. 5 as workers were transferring water between condensate storage tanks. A worker conducting routine rounds observed water leaking from an open test valve near the top of CST No. 5.

The NRC's standard was "no more than a few millirem per year" exposure to members of the public from offsite disposal methods. If NRC considered leaks and spills from transport accidents and found doses to meet the standard, that'd be one thing. But to apply a standard to a non-realistic situation (i.e., zero accidents) is misleading, at best, irresponsible, at worst.

There is no absolutely right, or wrong, answer to the question of what to do with spent fuel pool water after all spent fuel assemblies have been removed.

Contaminated water has leaked from spent fuel pools.

Contaminated water has been discharged from spent fuel pools into lakes, rivers, and oceans.

Contaminated water has been transported across the country and buried.

The least wrong answer is a disposal method that minimizes the risks – all the risks, not just a convenient subset of risks – to all persons.